SPATIAL AND TEMPORAL TRENDS OF ORGANOCHLORINE CONTAMINANTS IN SPOTTAIL SHINERS (NOTROPIS HUDSONIUS) FROM THE GREAT LAKES AND THEIR CONNECTING CHANNELS (1975 - 1988)

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SUMMARY

Collections of young-of-the-year (YOY) spottail shiners (Notropis hudsonius) were used as biomonitors to assess temporal and spatial trends of organochlorine contaminants in the nearshore waters of the Great Lakes.

Survey results showed that total PCB, total DDT and total chlordane concentrations in shiners from recent (1986 - 1988) collections were significantly ($p<0.05$) lower than residues in fish collections from the mid-1970's. Total PCB concentrations in shiners were negatively correlated ($p<0.05$) with time at 8 (30%) of 27 sites selected for temporal trend assessment. Total DDT concentrations were negatively correlated ($p<0.05$) with time at 9 (33%) sites, while total chlordane residues were negatively correlated ($p<0.05$) with time at 7 (26%) sites.

Total PCB concentrations in the recent (1986 - 88) YOY fish collections were in excess of the IJC Aquatic Life Guidelines(100 ng/g) at 30 (37%) of 82 sites sampled. Mirex concentrations exceeded the IJC Aquatic Life Guideline at 4 (21%) of the 19 Lake Ontario and Niagara River sites sampled, while octachlorostyrene levels were above the NYSDEC Fish Criterion (20 ng/g) at both of the 2 St. Clair River sites. None of the other contaminants detected exceeded the available Wildlife Protection Guidelines or Objectives.

A Forage Fish Contaminant Index, incorporating six organochlorine compounds was used to assess the significance of organochlorine accumulations in shiners. Wildlife Risk Levels were exceeded at 35 of 82 (43%) sites sampled.

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INTRODUCTION

Spottail shiners (Notropis hudsonius) have been used for contaminant biomonitoring in all the Great Lakes and connecting channels as part of the Great Lakes International Surveillance Plan (GLISP). Because of their localized nearshore habitat, spottail shiners are useful indicators of contaminant bioavailability for specific localities.

Since nearshore cyprinids are important forage fish (Scott and Crossman 1973), and contaminant concentrations are often higher in the nearshore water (Swackhamer and Armstrong 1987), forage fish provide an important link in the transfer of contaminants to higher trophic levels.

The main objective of this report is to summarize changes in water quality by assessing the present status and temporal trends of bioavailable organochlorine compounds from selected nearshore sites on the Great Lakes. Contaminant concentrations in forage fish were also used to assess compliance with IJC Aquatic Life Guidelines and the Fish Flesh Criteria of New York State (NYSDEC) (Newell et al. 1987) for site-specific and lake-wide assessments.

The findings and conclusions of this report were based on analytical data from young-of-the-year forage fish collected from the Great Lakes over a 13-year period (1975 - 1988). Portions of

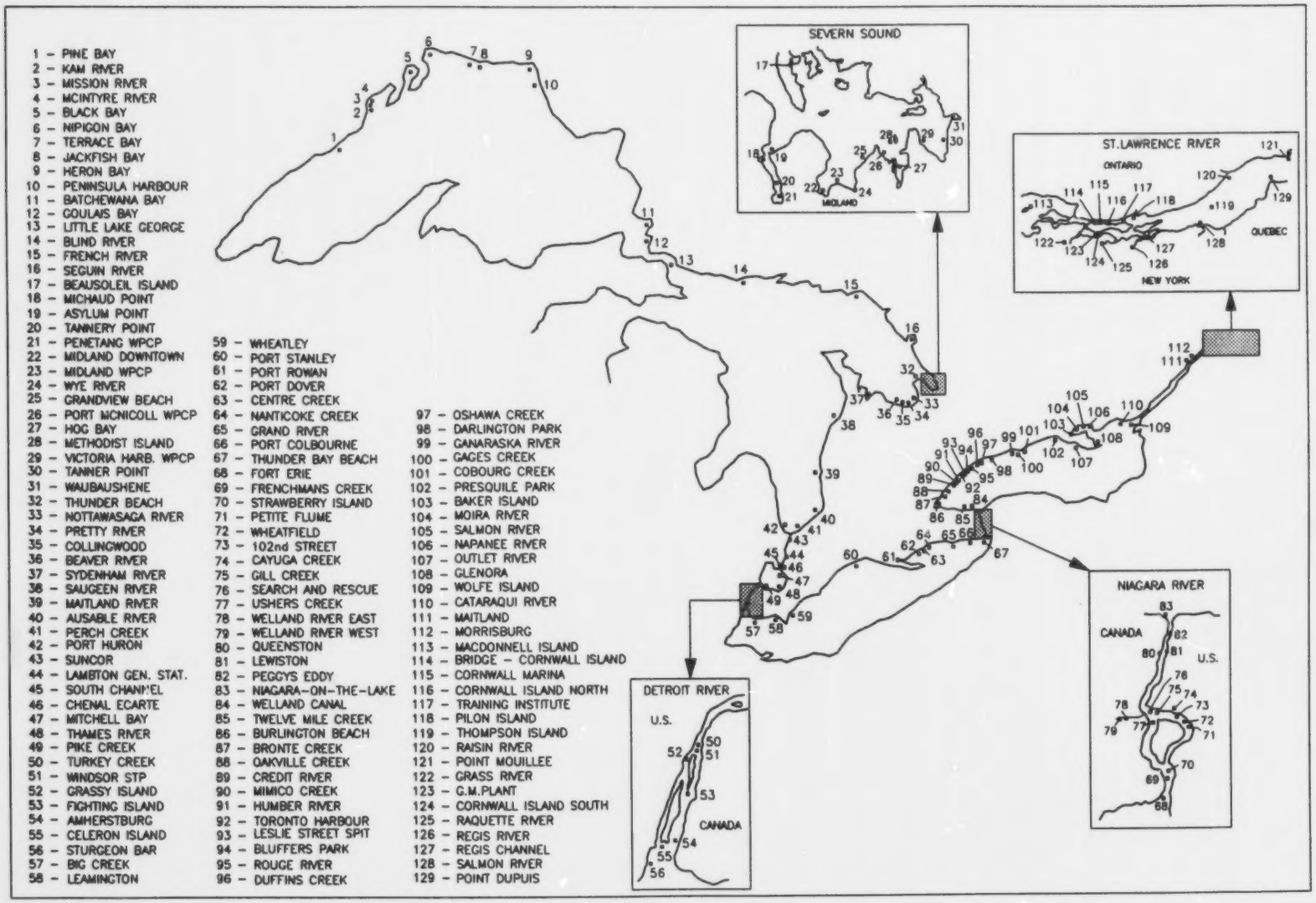
this data base have been published previously, either as Ontario Ministry of the Environment Technical Reports (Suns et al., 1985), or International Joint Commission's Great Lakes Water Quality Board publications (1987 and 1989).

METHODS

Young-of-the-year spottail shiners were collected annually during the month of September from nearshore sites throughout the Great Lakes and interconnecting channels (Figure 1). A 0.6 cm mesh bagseine was used for all collections.

Total lengths (T.L) of individual fish were determined, wrapped as ten fish composites in hexane-rinsed aluminum foil and frozen. Samples were stored at - 20°C before analysis. Whole-fish homogenates for each composite sample were analyzed for contaminant residues and lipid content. All contaminant residues except PAHs were identified and quantified at the Ontario Ministry of the Environment Laboratory in Rexdale. Megabore capillary (30 m x 0.53 mm, DB-5) gas chromatography was used for PCB, hexachlorobenzene (HCB), other chlorobenzenes, chlorophenols, toxaphene, heptachlor, mirex, aldrin, octachlorostyrene (OCS), p,p'DDE and p,p'DDD analysis, while narrow bore capillary (30 m x 0.25 mm, DB-5, DB1701) chromatography was used for chlordane, hexachlorocyclohexane (BHC), o,p'DDT and p,p'DDT (Ontario Ministry of the Environment 1981). Polynuclear Aromatic Hydrocarbon (PAH) residues were determined at ORTECH Laboratories in Mississauga. Gas chromatography methods were used with mass spectroscopy confirmation. Detection limits for most of the PAH compounds were 20 ng/g, DDT - 1 ng/g, mirex - 5 ng/g, chlordane 2 ng/g, HCB - 1 ng/g, OCS - 1 ng/g.

FIGURE 1: SPOTTAIL SHINER COLLECTION SITES IN THE GREAT LAKES AND CONNECTING CHANNELS.



Data used for spatial comparisons and site-specific ranking were taken from the last collection within the 2-year interval (1986 - 1988). One-Way Analysis of Variance (ANOVA) with Tukey Multiple Range Tests (TMRT) and Student's t-tests were used to determine statistical significance for spatial comparisons. A minimum of 5 years of data was used as a criterion for selecting sites for temporal trend assessment. Linear and geometric curve correlation analyses were used for trend assessments over time. Raw, log-transformed and lipid-normalized contaminant values were used for temporal trend assessment. Since the results were similar for all three methods, only the raw, wet-weight based values are shown graphically. Log-transformed data were used for the ANOVA and Tukey Multiple Range Tests.

A Forage Fish Contaminant Index (FFCI) was developed for site-to-site contaminant burden comparison. The Index was calculated by dividing actual contaminant concentrations in shiners by Wildlife Protection Guidelines or Objectives, then summing individual fractions. Six common organochlorine contaminants were used to calculate the Index. The Following International Joint Commission Aquatic Life Guidelines used were: PCB - 100 ng/g, mirex - 1 ng/g (IJC 1988; Great Lakes Water Quality Agreement, 1978). The following NYSDEC Fish Flesh Criteria were used: Total DDT - 200 ng/g, total chlordane - 500 ng/g, HCB - 330 ng/g, OCS - 20 ng/g (Newell et al., 1987).

SPATIAL PATTERNS OF ORGANOCHLORINE RESIDUES IN YOY SPOTTAIL SHINERS

Total PCB's

Although site-specific variances were evident within each of the waterbodies sampled, higher total PCB concentrations were generally found in shiners from the lower Great Lakes (Figure 2). Shiner samples from New York waters in the St. Lawrence and Michigan waters in the Detroit River had the highest PCB concentrations. Of the 82 collection sites reviewed in this survey, 30 (37%) had PCB concentrations in excess of the IJC Aquatic Life Guideline of 100 ng/g.

DDT and Metabolites

Total DDT residues, consisting mainly of p,p'DDE, were present in the majority of the shiner samples throughout the Great Lakes (Figure 3). The highest concentrations were found in collections from Lake Ontario. None of the samples analyzed had total DDT concentrations in excess of the Fish Flesh Criterion of 200 ng/g adopted for the protection of wildlife.

Total Chlordane

Chlordane residues were only found at 12 of the 82 collection sites sampled (Figure 4). The highest chlordane concentrations were in shiners from Lake Ontario. None of the collections had chlordane concentrations in excess of the Fish Flesh Criterion of 500 ng/g.

FIGURE 2: TOTAL PCB CONCENTRATIONS IN YOUNG-OF-THE-YEAR SPOTTAIL SHINERS FROM THE GREAT LAKES AND CONNECTING CHANNELS IN THE MOST RECENT YEAR, 1986, 1987, OR 1988. (N = NOT DETECTED, T = TRACE). IJC AQUATIC LIFE GUIDELINE FOR PCB = 100 ng/g .

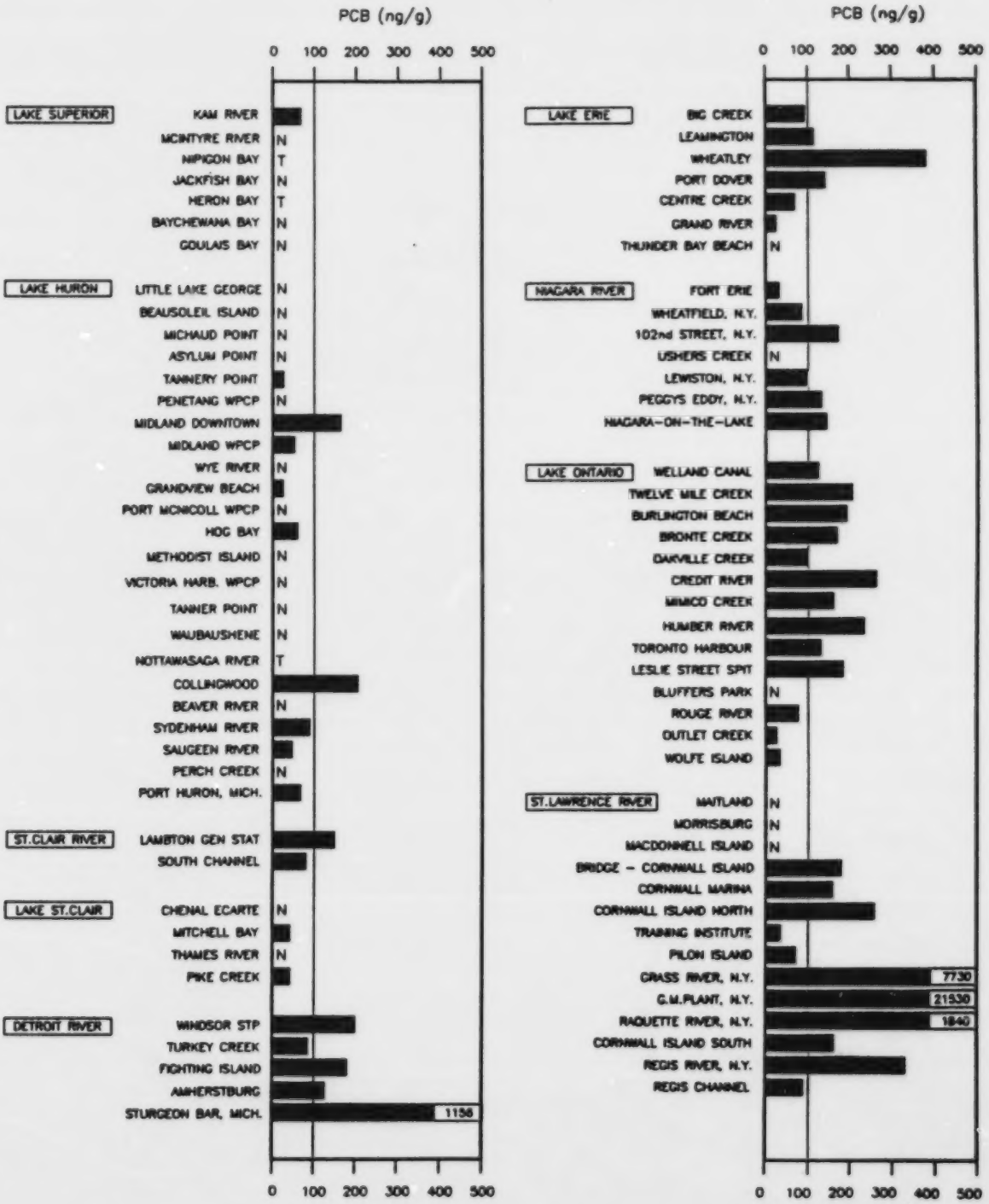


FIGURE 3: TOTAL DDT CONCENTRATIONS IN YOUNG-OF-THE-YEAR SPOTTAIL SHINERS FROM THE GREAT LAKES AND CONNECTING CHANNELS IN THE MOST RECENT YEAR, 1986, 1987, OR 1988. (N = NOT DETECTED, T = TRACE). NYSDEC FISH FLESH CRITERION FOR DDT = 200 ng/g .

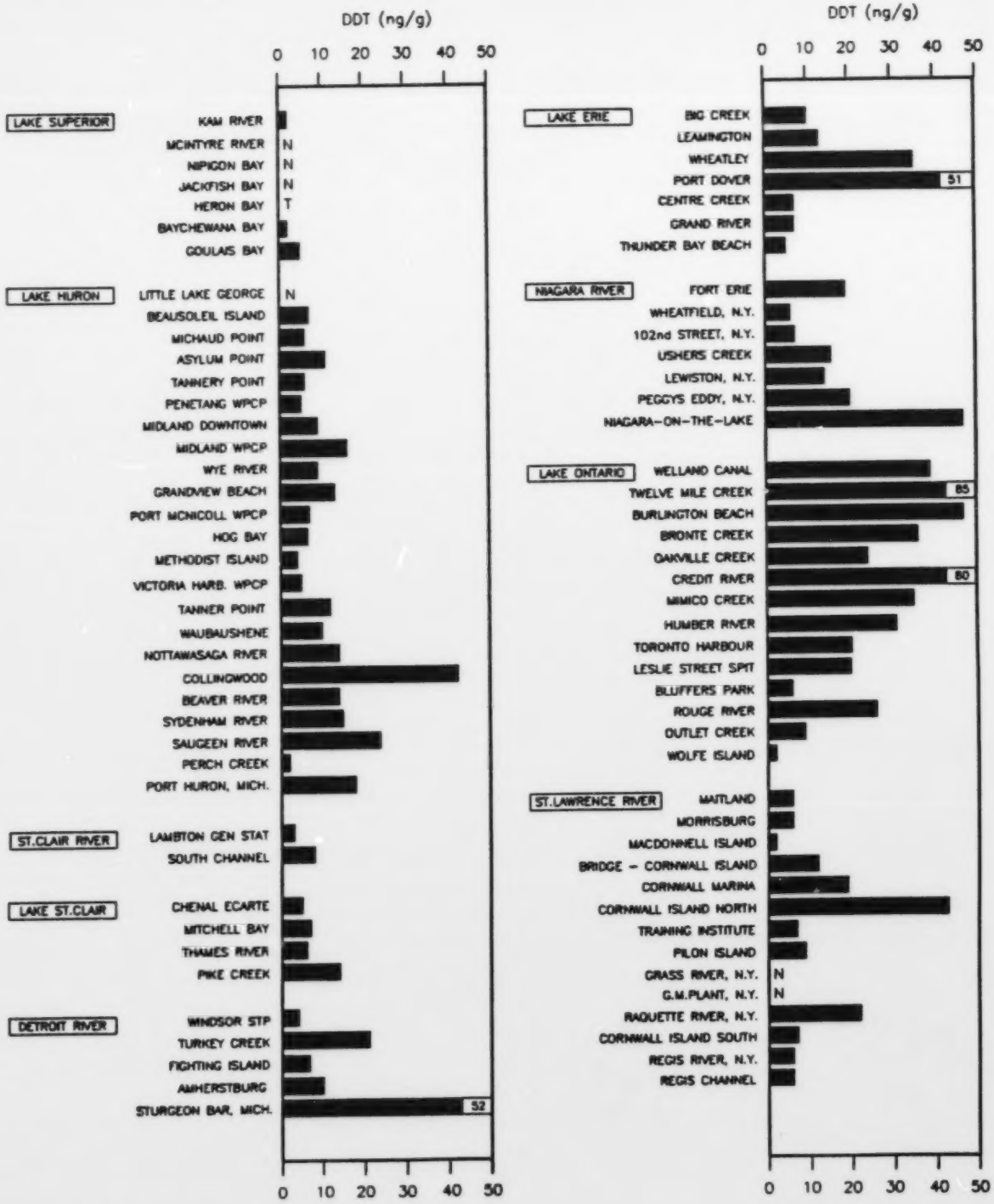
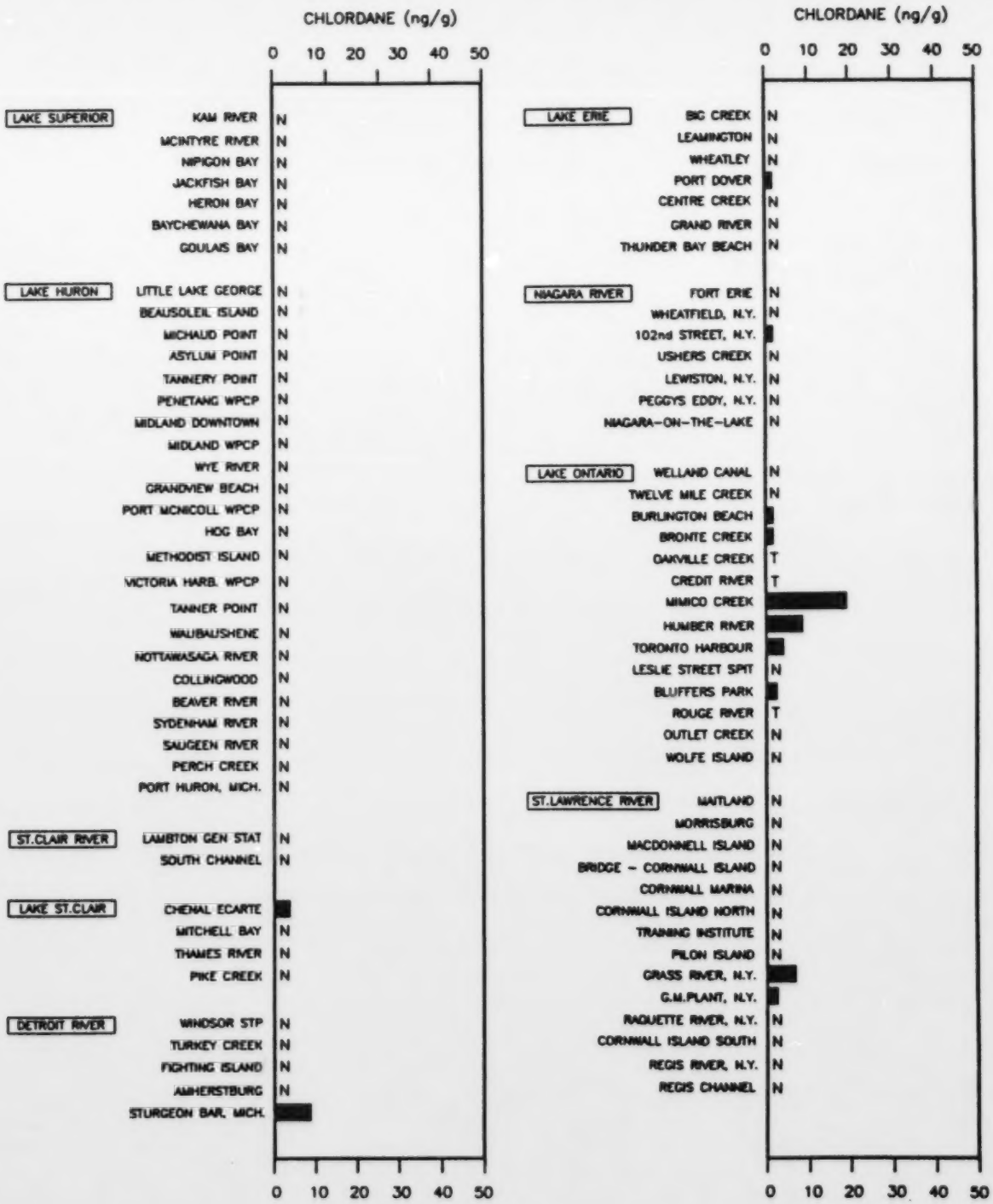


FIGURE 4: TOTAL CHLORDANE CONCENTRATIONS IN YOUNG-OF-THE-YEAR SPOTTAIL SHINERS FROM THE GREAT LAKES AND CONNECTING CHANNELS FOR THE MOST RECENT YEAR, 1986, 1987, OR 1988. (N = NOT DETECTED, T = TRACE). NYSDEC FISH FLESH CRITERION FOR CHLORDANE = 500 ng/g.



Mirex

Mirex residues in measurable concentrations were only found in 4 shiner collections from western Lake Ontario (Figure 5). Since the IJC Aquatic Life Guideline requires mirex to be "virtually absent" in biota, all 4 of the 14 (29%) Lake Ontario collections had mirex residues in excess of the Guideline. However, since the detection limit for mirex was 5 ng/g, the results of this survey may understate the extent of Guideline exceedance.

Octachlorostyrene (OCS)

All shiner samples from the St. Clair River, Lake St. Clair and the Detroit River had measurable OCS residues (Figure 6). Shiners from the St. Clair River had the highest OCS residues, and both collections had OCS concentrations in excess of the Fish Flesh Criterion of 20 ng/g. The elevated OCS availability in the St. Clair River has been linked to industrial inputs from the Sarnia industrial complex.

Hexachlorobenzene (HCB)

Spatial distribution patterns identified two main areas of HCB enrichment. Shiners from the St. Clair River and Niagara River collections had the highest HCB concentrations (Figure 7). Both St. Clair River collections originated downstream from the Sarnia industrial complex, while the 102nd Street site in Niagara Falls, N.Y. is linked to the Love Canal chemical disposal site. None of the shiner samples analyzed had HCB concentrations in excess of the Fish Flesh Criterion of 330 ng/g.

FIGURE 5: MIREX CONCENTRATIONS IN YOUNG-OF-THE-YEAR SPOTTAIL SHINERS FROM THE GREAT LAKES AND CONNECTING CHANNELS FOR THE MOST RECENT YEAR, 1986, 1987, OR 1988. (N = NOT DETECTED). IJC AQUATIC LIFE GUIDELINE FOR MIREX = ZERO.

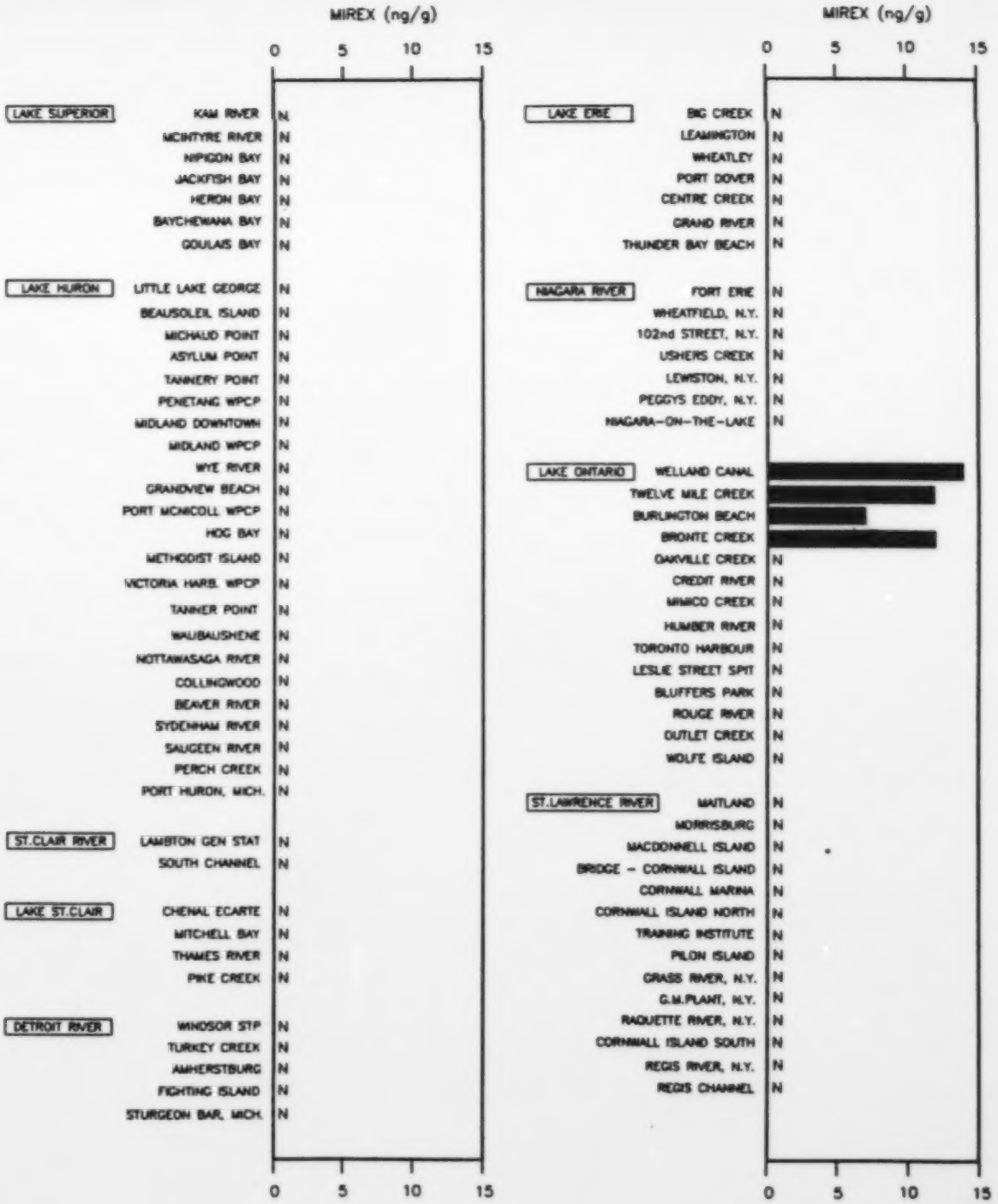


FIGURE 6: OCS CONCENTRATIONS IN YOUNG-OF-THE-YEAR SPOTTAIL SHINERS FROM THE GREAT LAKES AND CONNECTING CHANNELS FOR THE MOST RECENT YEAR, 1986, 1987, OR 1988. (N = NOT DETECTED, T = TRACE). NYSDEC FISH FLESH CRITERIA FOR OCS = 20 ng/g.

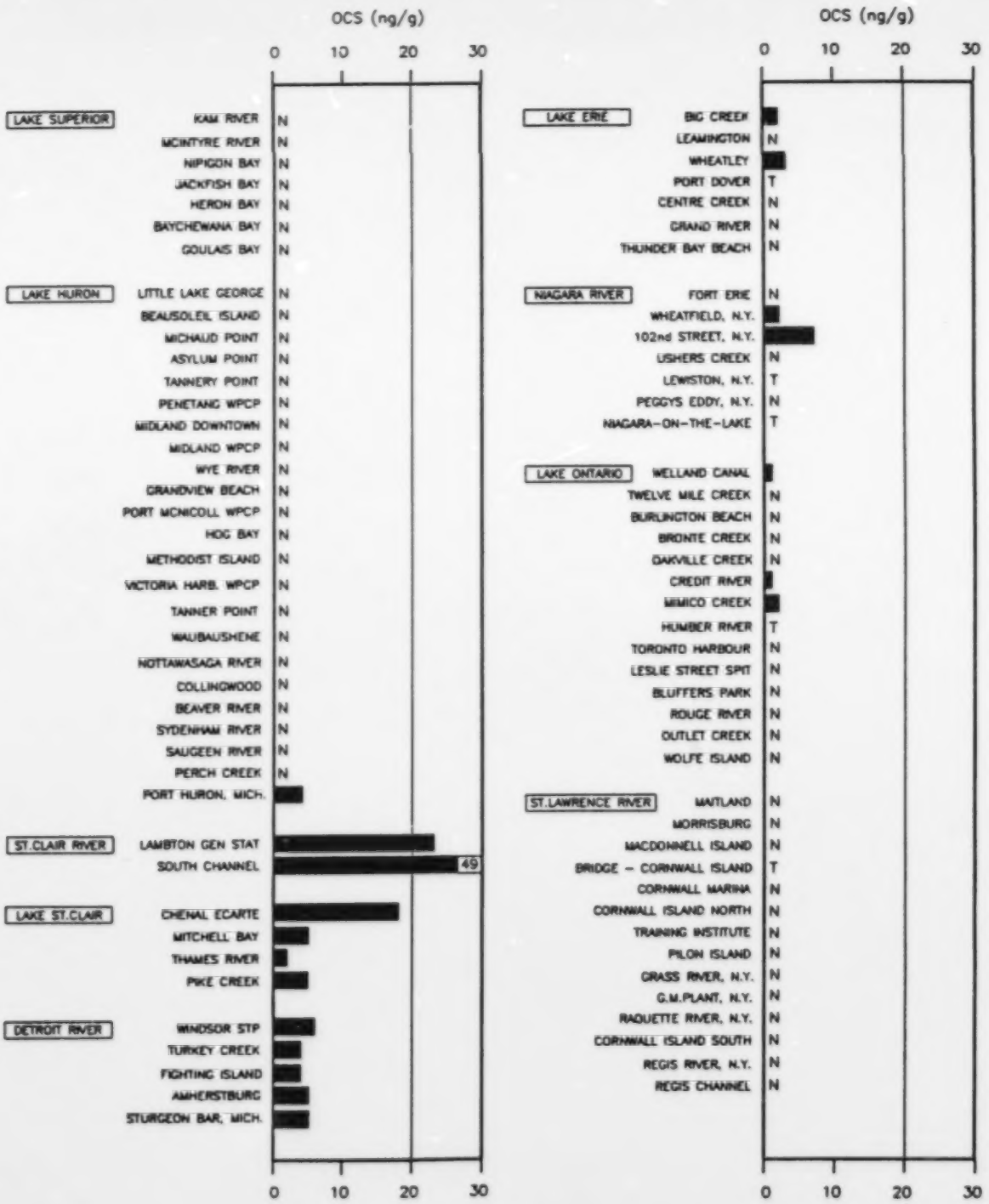
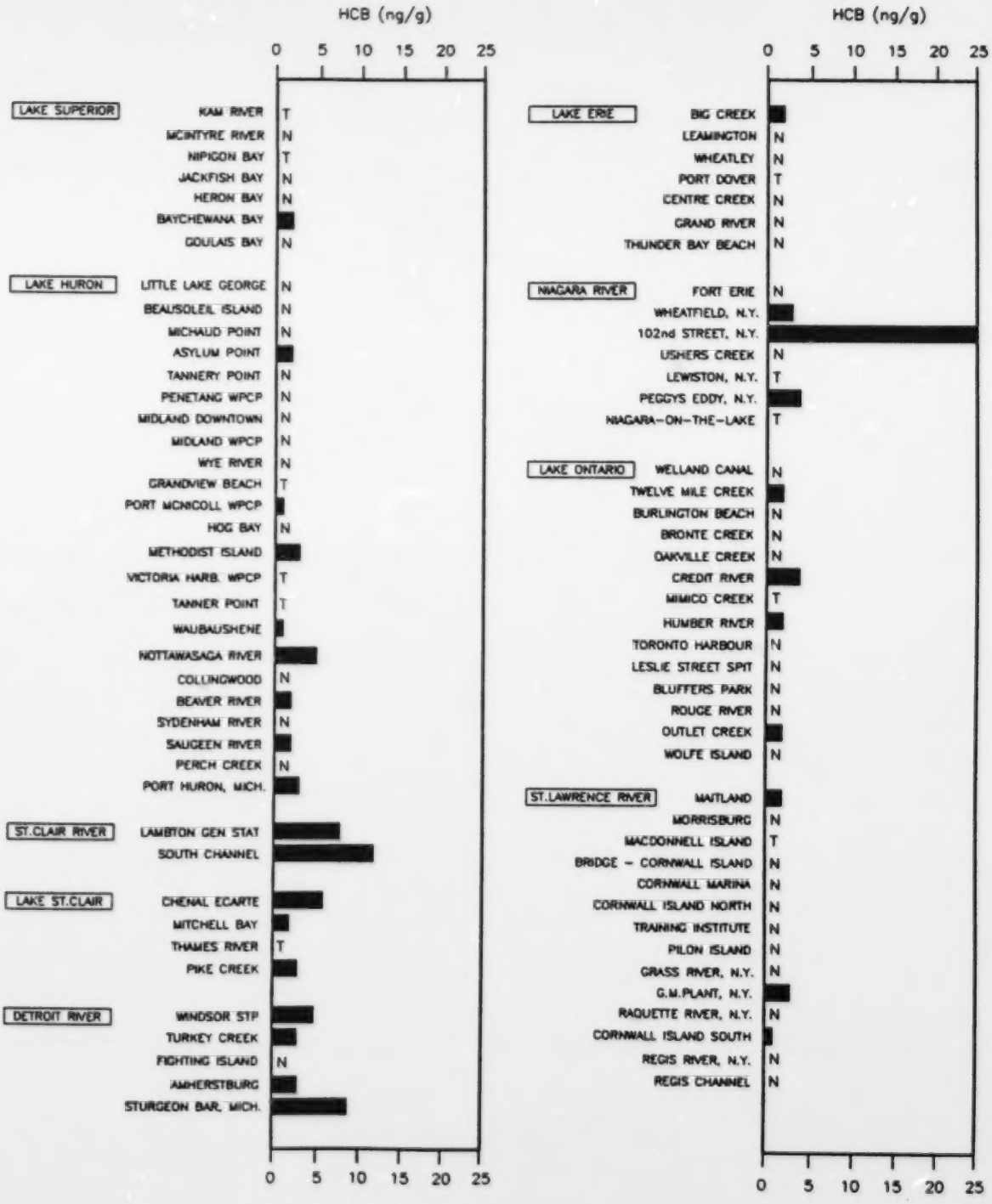


FIGURE 7: HCB CONCENTRATIONS IN YOUNG-OF-THE-YEAR SPOTTAIL SHINERS FROM THE GREAT LAKES AND CONNECTING CHANNELS FOR THE MOST RECENT YEAR, 1986, 1987, OR 1988. (N = NOT DETECTED, T = TRACE). NYSDEC FISH FLESH CRITERIA FOR HCB = 330 ng/g.



Forage Fish Contaminant Index (FFCI)

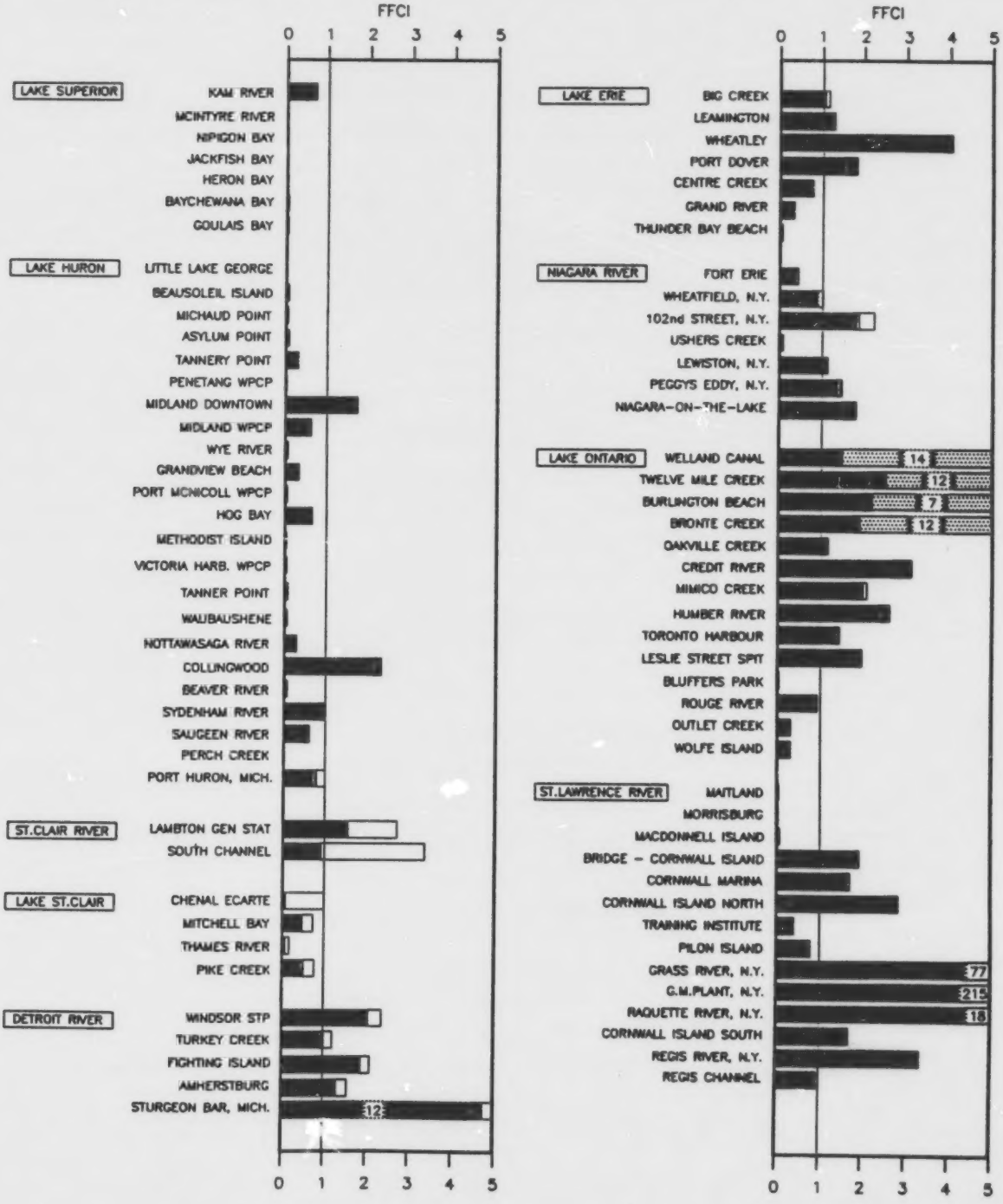
Considering that several organochlorine compounds are usually present in Great Lakes fishes, compound mixtures, rather than individual compounds provide the most realistic basis for assessing the significance of contaminant accumulations. Wildlife Protection Guidelines were used in this survey to assess risk levels for the given compound mix at each collection site.

The additivity of effects of individual compounds was assumed to be a valid concept for calculating the Index. Although documented support for the compounds used in this survey is lacking, the concept of additivity has been used by the U.S. EPA (1989) in establishing risk factors for mixtures of chlorinated dibenzo-p-dioxins and dibenzofurans.

Calculated FFCI values for each of the 82 collection sites are shown in Figure 8. The higher Index values represent higher risk factors in terms of Wildlife protection criteria, whereas all Index values higher than 1 suggest an area of concern. The Index value of 1 has been adopted as the Wildlife Risk Level. While Index values varied considerably from site-to-site, higher Index values were generally more frequent in shiner collections from the lower Great Lakes (Figure 8). The Wildlife Risk Level of 1 on the Index scale was exceeded in 35 of the 82 (43%) collections analyzed.

The relative contribution of PCBs towards the Index was high at most of the sites sampled. Mirex and octachlorostyrene were also significant contributors in Western Lake Ontario and the St. Clair River shiner collections respectively. Total DDT, chlordane and hexachlorobenzene were minor contributors.

FIG. 8: FORAGE FISH CONTAMINANT INDEX (FFCI) FOR CONTAMINANTS WITH WILDLIFE PROTECTION GUIDELINES OR OBJECTIVES. VALUES ARE THE SUM OF MEASURED CONCENTRATIONS IN YOUNG-OF-THE-YEAR SPOTTAIL SHINERS (MOST RECENT YEAR, 1986, 1987 OR 1988) DIVIDED BY THE GUIDELINE FOR EACH CONTAMINANT (■ PCB = 100ng/g, ■ DDT = 200ng/g, ▨ MIREX = 0 ng/g [used 1 ng/g], ▨ CHLORDANE = 500 ng/g, ■ HCB = 330 ng/g, AND □ OCS = 20 ng/g). WILDLIFE RISK LEVEL = 1.



LAKE SUPERIOR

Shiner collections from the Kaministiquia River estuary at Thunder Bay were the only collections from Lake Superior with measurable PCB concentrations (Figure 9; Appendix II). Differences between the mean concentrations of PCBs at the 7 Lake Superior sampling sites were significant (ANOVA; $F = 17.0$ $p<0.05$). The Tukey's Multiple Range test showed that Kam River collections had significantly ($p<0.05$) higher PCB concentrations than any of the other Lake Superior collections (Figure 10).

Although atmospheric inputs of PCBs to Lake Superior range from 755 - 7,550 kg/yr., (Thomann and Di Toro, 1983), PCB residues in the majority of shiner samples were below the detection limit. Significant differences (ANOVA; $F = 5.2$; $p<0.05$) of total DDT concentrations were found at the 7 sites sampled. The highest concentration was found in shiners from Goulais Bay and the lowest at McIntyre River and Nipigon Bay (Figures 9 & 10).

Hexachlorobenzene was only found in the Batchawana Bay collections. Chlordane, OCS, mirex, heptachlor, aldrin, toxaphene, BHC, other chlorobenzenes and chlorophenols were not detected.

FIGURE 9: LAKE SUPERIOR FORAGE FISH CONTAMINANT INDEX (FFCI) FOR CONTAMINANTS WITH WILDLIFE PROTECTION GUIDELINES OR OBJECTIVES. VALUES ARE THE SUM OF MEASURED CONCENTRATIONS IN YOY SPOTTAIL SHINERS (MOST RECENT YEAR, 1986, 1987 OR 1988) DIVIDED BY THE GUIDELINE FOR EACH CONTAMINANT. WILDLIFE RISK LEVEL = 1. (N = NOT DETECTED, T = TRACE).

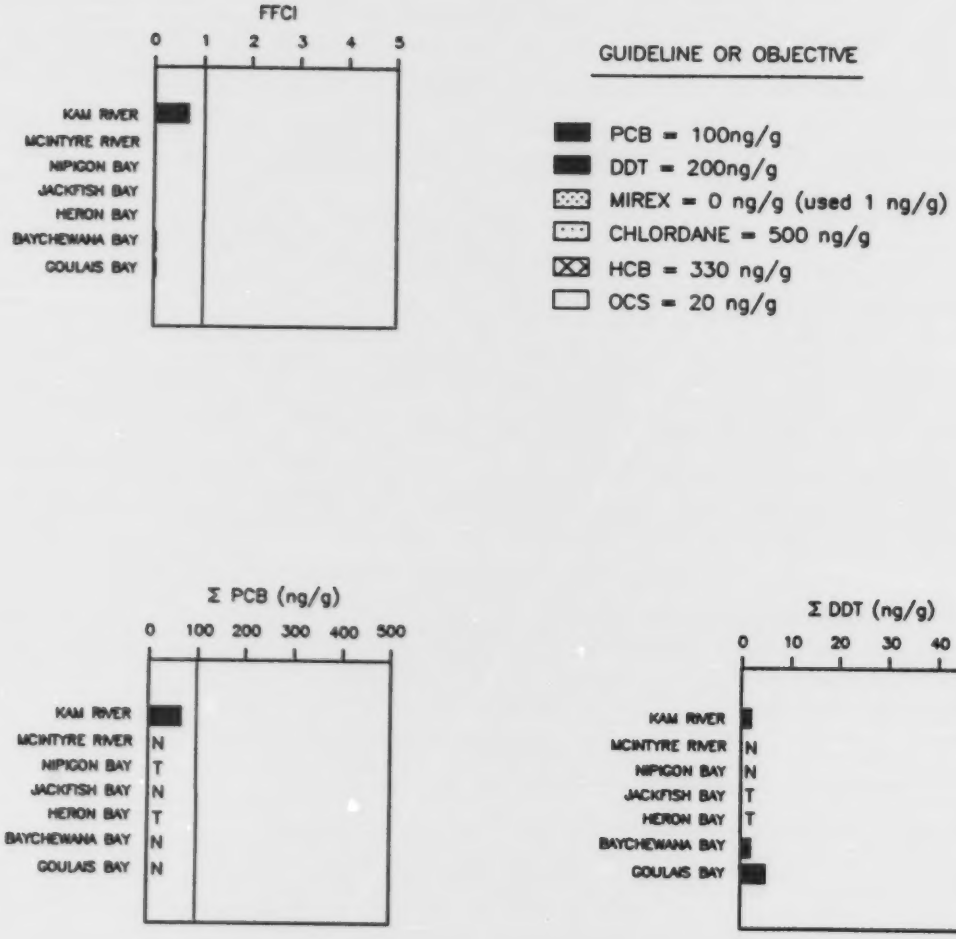
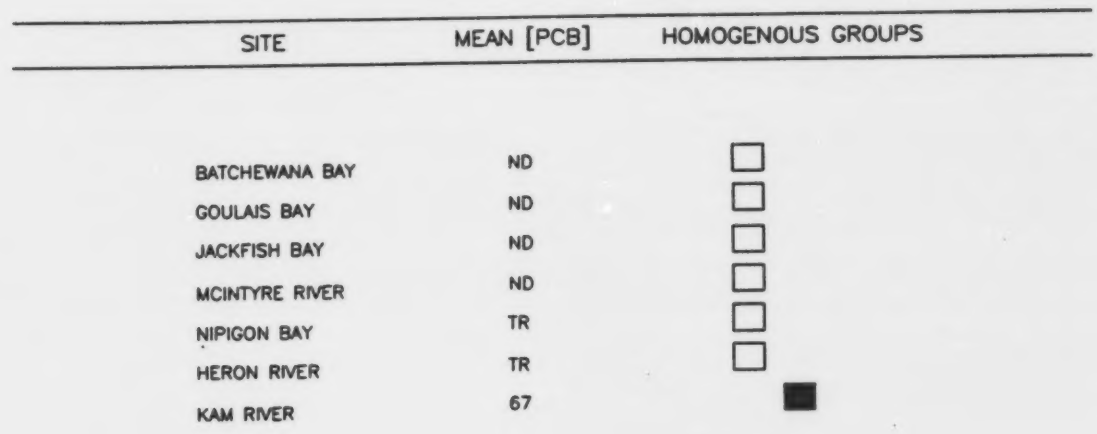


FIGURE 10: SITE-SPECIFIC COMPARISON OF PCB RESIDUES (ng/g) IN YOUNG-OF-THE-YEAR SPOTTAIL SHINERS FROM LAKE SUPERIOR FOR THE MOST RECENT YEAR, 1986,1987 OR 1988, USING TUKEY'S MULTIPLE RANGE TEST (95% CONFIDENCE LIMITS) ON LOG TRANSFORMED DATA. (ND = NOT DETECTED; TR = TRACE).

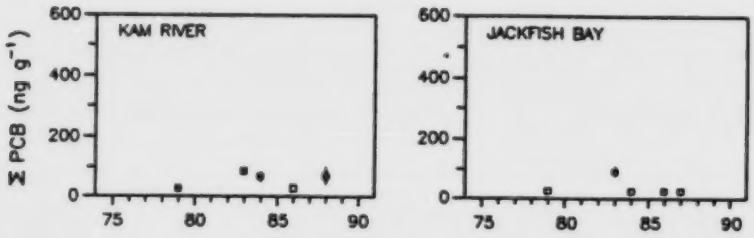


SITE-SPECIFIC COMPARISON OF DDT RESIDUES (ng/g) IN YOUNG-OF-THE-YEAR SPOTTAIL SHINERS FROM LAKE SUPERIOR FOR THE MOST RECENT YEAR, 1986,1987 OR 1988, USING TUKEY'S MULTIPLE RANGE TEST (95% CONFIDENCE LIMITS) ON LOG TRANSFORMED DATA. (ND = NOT DETECTED; TR = TRACE).

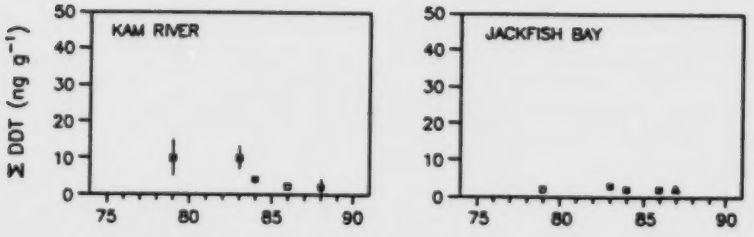
Low concentrations of Polynuclear Aromatic Hydrocarbons (PAH's), consisting of naphthalene and phenanthrene were also found in shiners from the Kam River and Goulais Bay collection (Appendix III). Guidelines are not available to assess the importance of these PAH accumulations.

Only the Kam River and Jackfish Bay collections had sufficient data for temporal trend assessment. No significant ($p>0.05$) correlations with time were found for total PCB, DDT and chlordane residues in spottail shiners at either one of the collection sites (Figure 11).

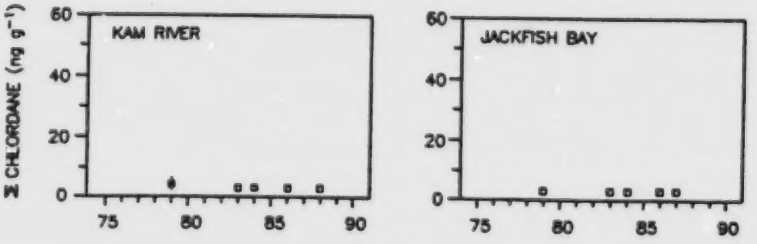
FIGURE 11: TEMPORAL TRENDS OF Σ PCB CONCENTRATIONS IN YOUNG-OF-THE-YEAR SPOTTAIL SHINERS FROM LAKE SUPERIOR. VALUES ARE MEANS +/- 95% CONFIDENCE LIMITS. SIGNIFICANT CORRELATIONS WITH TIME (P<0.05) ARE INDICATED WITH A STRAIGHT LINE.



TEMPORAL TRENDS OF Σ DDT CONCENTRATIONS IN YOUNG-OF-THE-YEAR SPOTTAIL SHINERS FROM LAKE SUPERIOR. VALUES ARE MEANS +/- 95% CONFIDENCE LIMITS. SIGNIFICANT CORRELATIONS WITH TIME (P<0.05) ARE INDICATED WITH A STRAIGHT LINE.



TEMPORAL TRENDS OF Σ CHLORDANE CONCENTRATIONS IN YOUNG-OF-THE-YEAR SPOTTAIL SHINERS FROM LAKE SUPERIOR. VALUES ARE MEANS +/- 95% CONFIDENCE LIMITS. SIGNIFICANT TRENDS WITH TIME (P<0.05) ARE INDICATED WITH A STRAIGHT LINE.



□ – NOT DETECTED
△ – TRACE AMOUNT

LAKE HURON/SEVERN SOUND

Since the majority of Lake Huron collections were from Severn Sound, Severn Sound collection sites are shown separately in Figure 12 and Appendix IV. Of the 22 sites sampled in Lake Huron (Appendices I and IV), 9 sites had shiners with measurable PCB concentrations (Figures 12 and 13). Differences between the mean concentrations of PCB at the 22 Lake Huron sites were significant (ANOVA; $F = 44.3$; $p<0.05$). PCBs were not detected at 13 collection sites (Figure 14). The highest PCB concentrations were found in the Collingwood and Midland collections. In comparison to the high PCB concentrations in the Collingwood collections, only trace levels of PCBs were found in shiners at Nottawasaga River, near Collingwood. It may, therefore, be concluded that local sources play a major role in PCB enrichment at Collingwood Harbour.

The DDT metabolite p,p'DDE was found in all samples, except the one from Lake George (Figure 13). While the spatial distribution of total DDT was more uniform than that of PCBs, as indicated by the overlap of groups of several sampling sites (Figure 15), differences between the mean total DDT concentrations were significant (ANOVA: $F = 12.7$; $p<0.05$). The highest total DDT concentration was found in the Collingwood Harbour samples and the lowest in the Little Lake George and

FIGURE 12: SEVERN SOUND FORAGE FISH CONTAMINANT INDEX (FFCI) FOR CONTAMINANTS WITH WILDLIFE PROTECTION GUIDELINES OR OBJECTIVES. VALUES ARE THE SUM OF MEASURED CONCENTRATIONS IN YOY SPOTTAIL SHINERS (MOST RECENT YEAR, 1986, 1987 OR 1988) DIVIDED BY THE GUIDELINE FOR EACH CONTAMINANT. WILDLIFE RISK LEVEL = 1. (N = NOT DETECTED, T = TRACE).

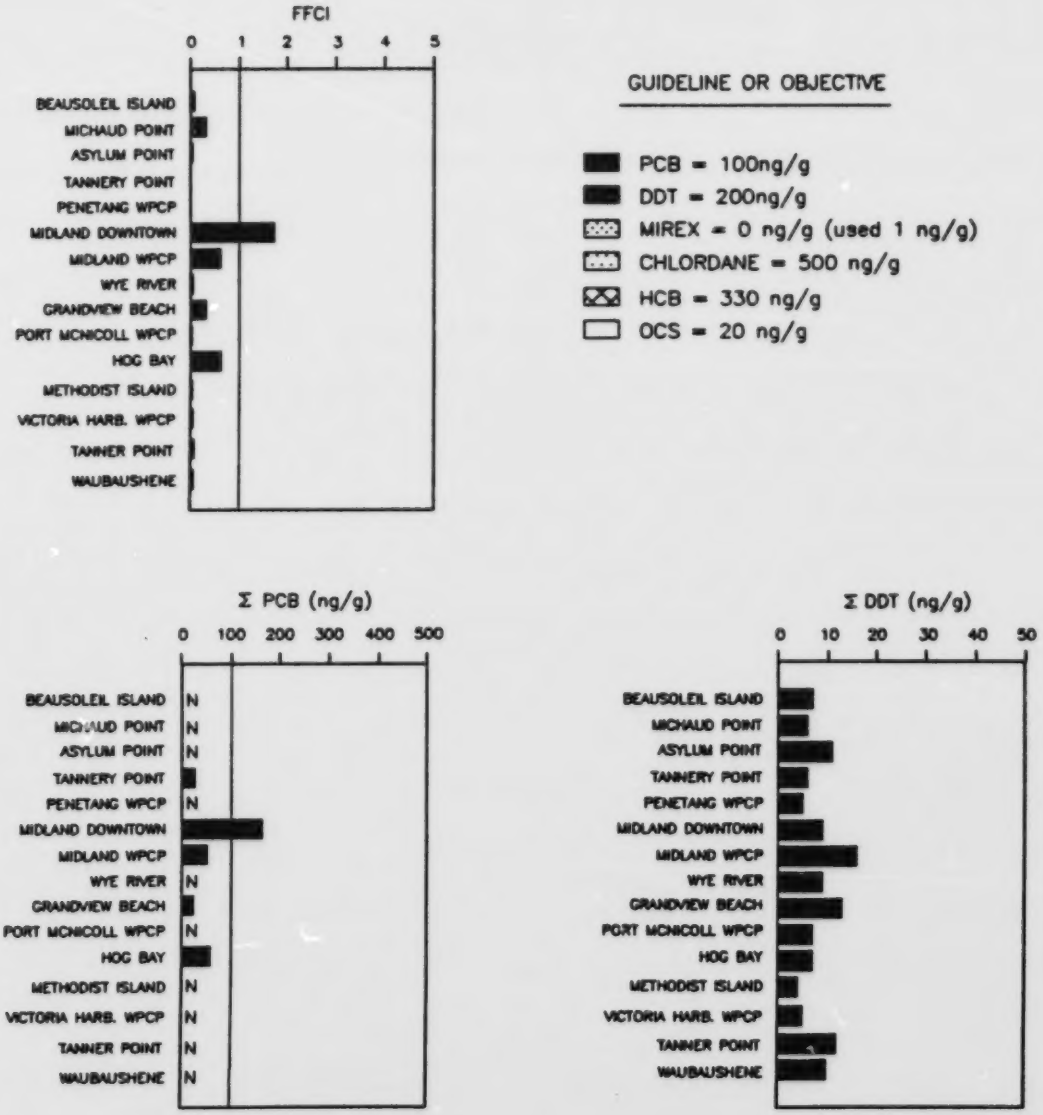


FIGURE 13: LAKE HURON FORAGE FISH CONTAMINANT INDEX (FFCI) FOR CONTAMINANTS WITH WILDLIFE PROTECTION GUIDELINES OR OBJECTIVES. VALUES ARE THE SUM OF MEASURED CONCENTRATIONS IN YOY SPOTTAIL SHINERS (MOST RECENT YEAR, 1986, 1987 OR 1988) DIVIDED BY THE GUIDELINE FOR EACH CONTAMINANT. WILDLIFE RISK LEVEL = 1. (N = NOT DETECTED, T = TRACE).

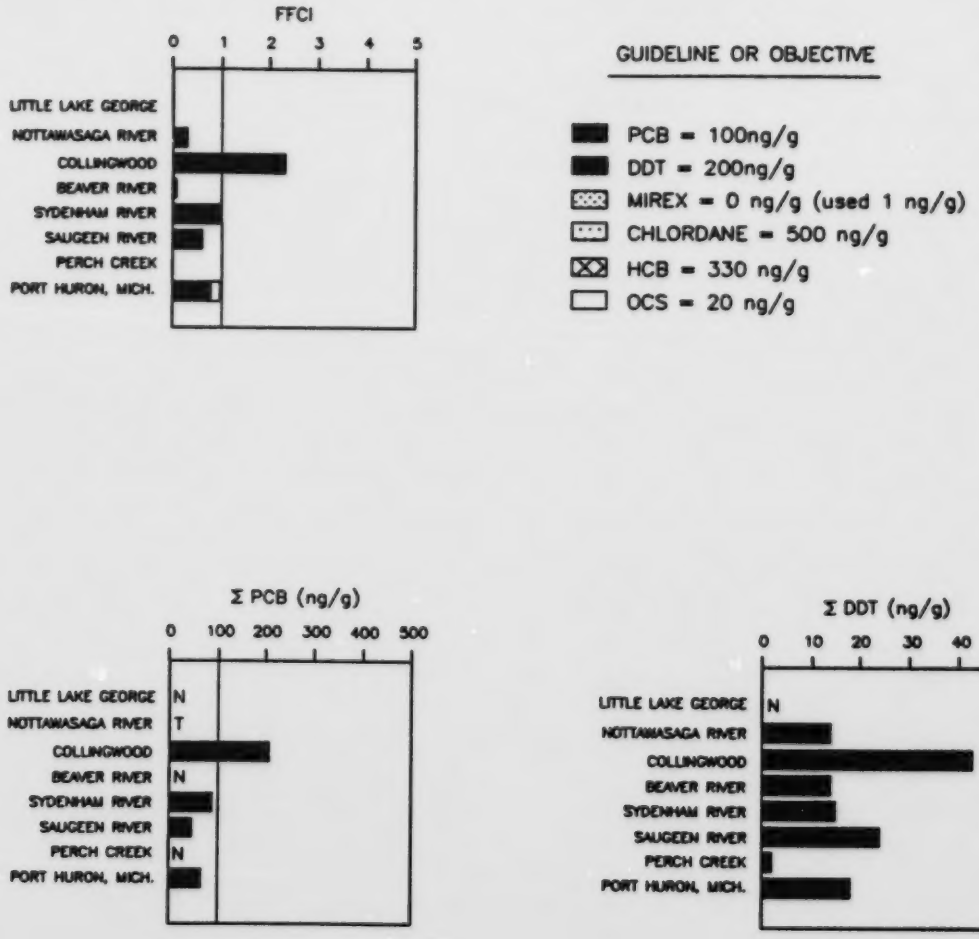


FIGURE 14: SITE-SPECIFIC COMPARISON OF PCB RESIDUES (ng/g) IN YOUNG-OF-THE-YEAR SPOTTAIL SHINERS FROM LAKE HURON FOR THE MOST RECENT YEAR (1986, 1987 OR 1988), USING TUKEY'S MULTIPLE RANGE TEST (95% CONFIDENCE LIMITS) ON LOG TRANSFORMED DATA. (ND = NOT DETECTED; TR = TRACE).

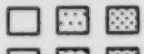
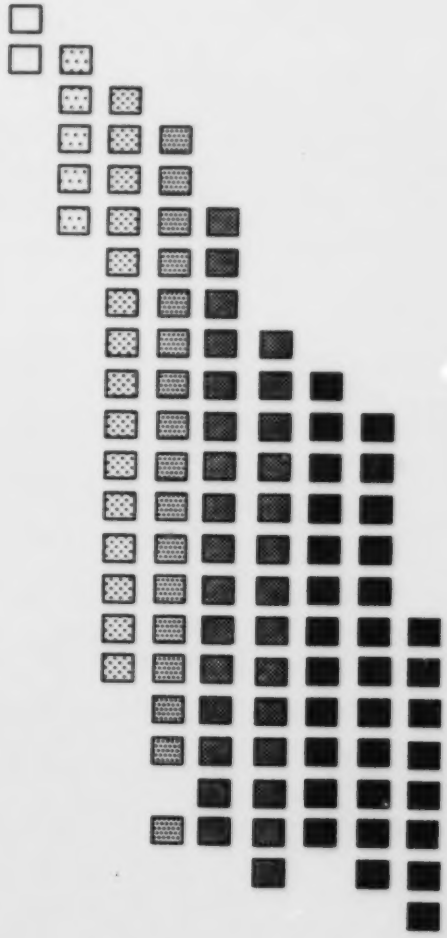
SITE	MEAN [PCB]	HOMOGENOUS GROUPS
ASYLUM POINT	ND	
BEAUSOLEIL ISLAND	ND	
BEAVER RIVER	ND	
LITTLE LAKE GEORGE	ND	
METHODIST ISLAND	ND	
MICHAUD POINT	ND	
PENETANG WPCP	ND	
PERCH CREEK	ND	
PORT MCNICOLL WPCP	ND	
TANNER POINT	ND	
VICTORIA HARBOUR WPCP	ND	
WAUBAUSHENE	ND	
WYE RIVER	ND	
NOTTAWASAGA RIVER	TR	
GRANDVIEW BEACH	24	
TANNERY POINT	27	
SAUGEEN RIVER	47	
MIDLAND WPCP	52	
HOG BAY	59	
PORT HURON	67	
SYDENHAM RIVER	89	
MIDLAND DOWNTOWN	164	
COLLINGWOOD	206	

FIGURE 15: SITE-SPECIFIC COMPARISON OF DDT RESIDUES (ng/g) IN YOUNG-OF-THE-YEAR SPOTTAIL SHINERS FROM LAKE HURON FOR THE MOST RECENT YEAR (1986, 1987 OR 1988), USING TUKEY'S MULTIPLE RANGE TEST (95% CONFIDENCE LIMITS) ON LOG TRANSFORMED DATA. (ND = NOT DETECTED).

SITE	MEAN [DDT]	HOMOGENOUS GROUPS
LITTLE LAKE GEORGE	ND	
PERCH CREEK	2	
METHODIST ISLAND	4	
PENETANG WPCP	5	
MICHAUD POINT	6	
VICTORIA HARBOUR WPCP	5	
TANNERY POINT	6	
BEAUSOLEIL ISLAND	7	
PORT MCNICOLL WPCP	7	
HOG BAY	7	
MIDLAND DOWNTOWN	9	
WYE RIVER	9	
WAUBAUSHENE	10	
ASYLUM POINT	11	
TANNER POINT	12	
NOTTAWASAGA RIVER	13	
MIDLAND WPCP	16	
GRANDVIEW BEACH	13	
BEAVER RIVER	13	
SYDENHAM RIVER	15	
PORT HURON	18	
SAUGEEN RIVER	24	
COLLINGWOOD	43	

Perch Creek collections (Figure 13). The Collingwood Harbour collections had 23% p,p'DDD, whereas all other collections contained only p,p'DDE. This likely indicates more recent use of DDT, since p,p'DDD is less stable than p,p'DDE (Aguilar, 1984). Low concentrations of HCB were present in several of the Lake Huron collections. Chlordane, OCS, mirex heptachlor, aldrin, toxaphene, BHC and other chlorobenzenes were not detected. The IJC Aquatic Life Guideline of 100 ng/g for PCBs was exceeded at Collingwood Harbour and Midland (Figure 12).

The Forage Fish Contaminant Index values for Lake Huron shiners generally followed the residue distribution pattern of PCBs, except for the increased Risk Level at Collingwood, contributed by total DDT (Figure 13). Wildlife Risk Level was also reached, but not exceeded, at Sydenham River and Port Huron with contributions of total DDT and OCS respectively.

Of interest is the PAH accumulation in one of the shiner samples from Collingwood Harbour (Appendix III). PAHs found in the Collingwood Harbour sample were generally much higher than PAH residues in comparable samples from the Great Lakes. Although PAH concentrations in one of the shiner samples was elevated, it should be noted that PAHs in two other samples from the same collection were not detected. PAH data from benthic

biota and sediment surveys do not support the results of juvenile fish indicating PAH enrichment in the Collingwood Harbour (MOE unpublished data). No Guidelines are available to assess the importance of these PAH levels in shiners.

None of the Lake Huron collections had sufficient contaminant data for temporal trend assessment. However, PCB, DDT, chlordane and HCB concentrations in the Nottawasaga River and Perch Creek collections appeared to be declining (Appendix II).

ST. CLAIR AND DETROIT RIVERS

Total PCB concentrations were significantly different (ANOVA; $F = 67.6$; $p<0.05$) at the 7 St. Clair and Detroit sites sampled (Figure 16).

The highest concentrations were found in samples from the Detroit River at Sturgeon Bar, while the lowest were in shiners from the St. Clair River at the South Channel (Figures 16 and 17). PCB concentrations in shiners from the St. Clair River at Lambton Power Generating Station were significantly ($p<0.05$) higher than PCBs in samples from South Channel, a site further downstream from the Sarnia industrial complex (Figure 17; Appendix V). Elevated PCB concentrations have been found in previous shiner collections from the Sturgeon Bar (Suns et al., 1985). Caged mussel studies have also shown higher PCB availability along the Michigan shoreline (Kauss and Hamdy, 1985). Sediment surveys show that high PCB concentrations in Trenton Channel originated from the transport of contaminated sediments (Furlong et al., 1988; Oliver and Burbonniere, 1985; Kaiser et al., 1985; Hamdy and Post, 1985). PCB concentrations in all the Detroit River shiner collections were significantly ($p<0.05$) higher than PCBs in shiners from Pike Creek, at the south-western extremity of Lake St. Clair. Therefore, it may be concluded that there are PCB inputs within the Detroit River basin (Figure 17, Appendix II).

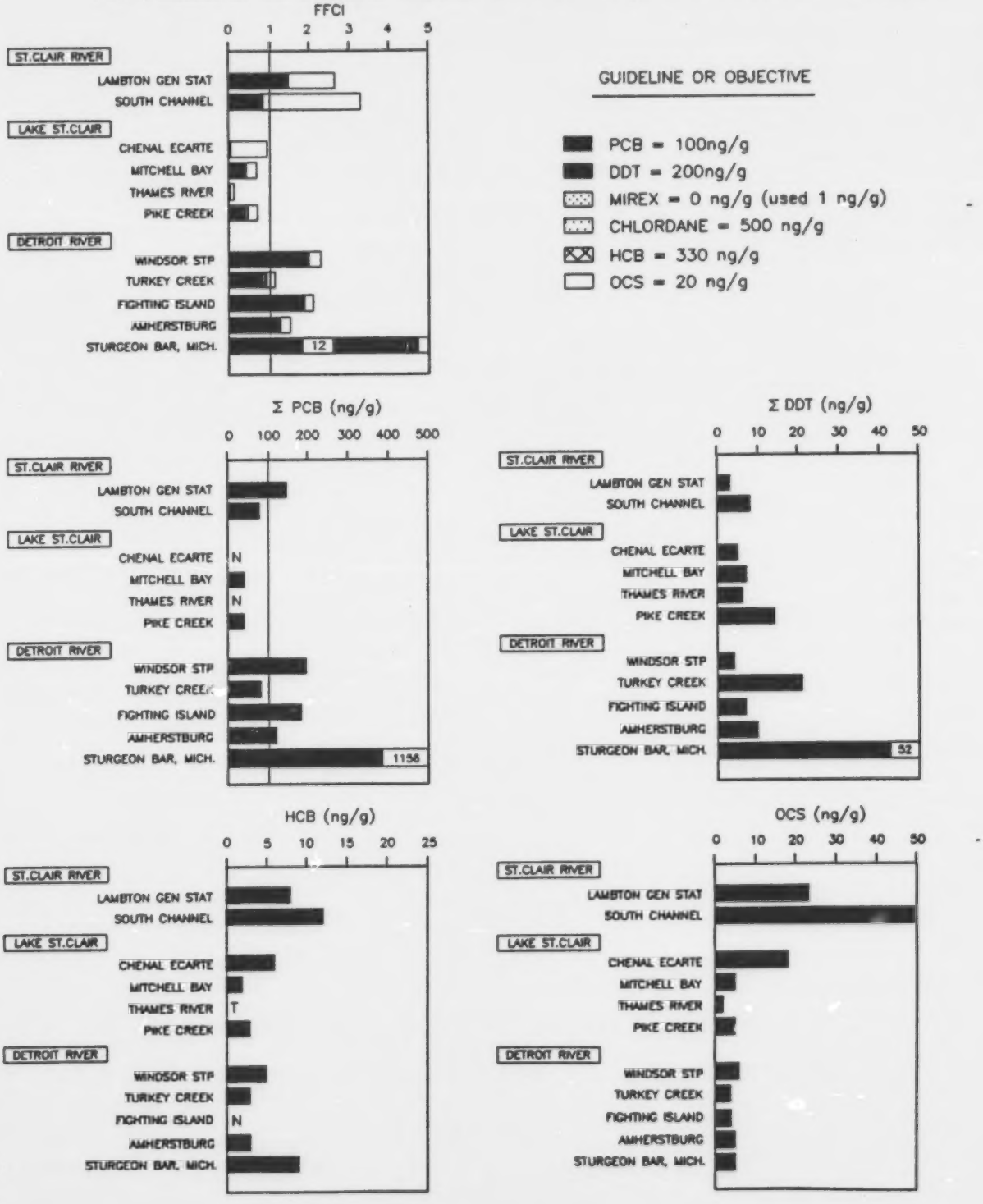
FIGURE 16: SITE-SPECIFIC COMPARISON OF PCB RESIDUES (ng/g) IN YOUNG-OF-THE-YEAR SPOTTAIL SHINERS FROM THE ST.CLAIR RIVER AND THE DETROIT RIVER FOR THE MOST RECENT YEAR, 1986, 1987 OR 1988, USING TUKEY'S MULTIPLE RANGE TEST (95% CONFIDENCE LIMITS) ON LOG TRANSFORMED DATA.

SITE	MEAN [PCB]	HOMOGENOUS GROUPS
SOUTH CHANNEL	79	
TURKEY CREEK	84	
AMHERSTBURG	124	
LAMBTON GENERATING STATION	148	
FIGHTING ISLAND	184	
WINDSOR STP	198	
STURGEON BAR, MICH.	1156	

SITE-SPECIFIC COMPARISON OF DDT RESIDUES (ng/g) IN YOUNG-OF-THE-YEAR SPOTTAIL SHINERS FROM THE ST.CLAIR RIVER AND THE DETROIT RIVER FOR THE MOST RECENT YEAR, 1986, 1987 OR 1988, USING TUKEY'S MULTIPLE RANGE TEST (95% CONFIDENCE LIMITS) ON LOG TRANSFORMED DATA.

SITE	MEAN [DDT]	HOMOGENOUS GROUPS
LAMBTON GENERATING STATION	3	
WINDSOR STP	4	
FIGHTING ISLAND	7	
SOUTH CHANNEL	8	
AMHERSTBURG	10	
TURKEY CREEK	21	
STURGEON BAR, MICH.	52	

FIGURE 17: ST.CLAIR RIVER, LAKE ST.CLAIR AND DETROIT RIVER FORAGE FISH CONTAMINANT INDEX (FFCI) FOR CONTAMINANTS WITH WILDLIFE PROTECTION GUIDELINES OR OBJECTIVES. VALUES ARE THE SUM OF MEASURED CONCENTRATIONS IN YOY SPOTTAIL SHINERS (MOST RECENT YEAR, 1986, 1987 OR 1988) DIVIDED BY THE GUIDELINE. WILDLIFE RISK LEVEL = 1. (N = NOT DETECTED, T = TRACE).



Differences between the mean concentrations of hexachlorobenzene in the 7 St. Clair and Detroit River collections were significant (ANOVA; $F = 23.0$; $p<0.05$). The highest HCB concentrations were found in the South Channel samples from St. Clair River and the lowest at Fighting Island from Detroit River (Figure 18). Significant differences were also found among octachlorostyrene concentrations (ANOVA; $F = 45.7$; $p<0.05$). The highest OCS concentrations were found in shiners from South Channel and the lowest at Turkey Creek (Figures 17 & 18). Results from caged mussel studies (Kauss and Hamdy, 1985), and sediment surveys (Oliver and Burbonniere, 1985) have also shown that OCS and HCB availability in the St. Clair River is high. Dow Chemical of Sarnia has been identified as a major source of HCB and OCS (DOE/MOE, 1986). There is no evidence from the shiner survey that inputs of HCB and OCS existed in the Detroit River basin.

Mean concentrations of total DDT were significantly different at the 7 St. Clair and Detroit River collection sites (ANOVA; $F = 11.5$; $P<0.05$). The highest DDT concentrations were found in shiners from the Sturgeon Bar, and the lowest at Lambton Power Generation Plant (Figures 16 & 17). In addition to p,p'DDE, Sturgeon Bar samples also contained p,p'DDD, constituting 23% of the total DDT residue.

FIGURE 18: SITE-SPECIFIC COMPARISON OF HCB RESIDUES (ng/g) IN YOUNG-OF-THE-YEAR SPOTTAIL SHINERS FROM THE ST.CLAIR RIVER AND THE DETROIT RIVER FOR THE MOST RECENT YEAR, 1986, 1987 OR 1988, USING TUKEY'S MULTIPLE RANGE TEST (95% CONFIDENCE LIMITS) ON LOG TRANSFORMED DATA.

SITE	MEAN [HCB]	HOMOGENOUS GROUPS
FIGHTING ISLAND	3	
AMHERSTBURG	3	
TURKEY CREEK	3	
WINDSOR STP	6	
LAMBTON GENERATING STATION	8	
STURGEON BAR, MICH.	9	
SOUTH CHANNEL	12	

SITE-SPECIFIC COMPARISON OF OCS RESIDUES (ng/g) IN YOUNG-OF-THE-YEAR SPOTTAIL SHINERS FROM THE ST.CLAIR RIVER AND THE DETROIT RIVER FOR THE MOST RECENT YEAR, 1986, 1987 OR 1988, USING TUKEY'S MULTIPLE RANGE TEST (95% CONFIDENCE LIMITS) ON LOG TRANSFORMED DATA.

SITE	MEAN [OCS]	HOMOGENOUS GROUPS
TURKEY CREEK	4	
FIGHTING ISLAND	4	
AMHERSTBURG	5	
WINDSOR STP	5	
STURGEON BAR, MICH.	5	
LAMBTON GENERATING STATION	23	
SOUTH CHANNEL	49	

Total PCB concentration in the Lambton Power Generation Plant collection exceeded the IJC Aquatic Life Guideline of 100 ng/g. OCS concentrations in both St. Clair River collections exceeded the 20 ng/g NYSDEC Fish Flesh Criterion. Contributions from OCS raised the Forage Fish Contaminant Index considerably in both of the St. Clair collections (Figure 17). As a result of PCB and OCS availability, the FFCI values for the St. Clair River shiners were well above the Wildlife Risk Level of 1 on the FFCI scale.

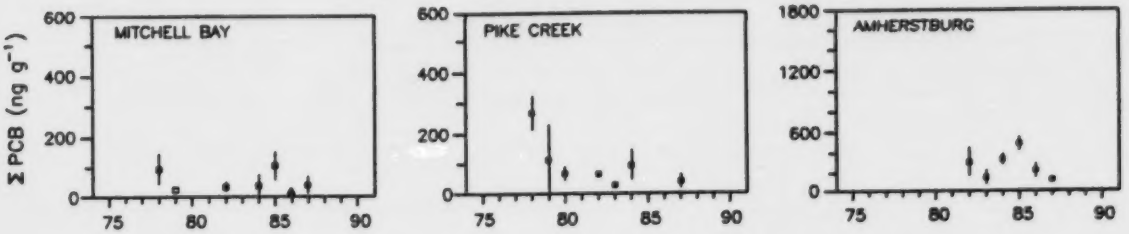
Four of 5 (80%) shiner collections from the Detroit River had PCB concentrations in excess of the IJC Aquatic Life Guideline of 100 ng/g (Figure 17). Contributions from total DDT and OCS raised the Forage contaminant Index in all 5 Detroit River samples to the extent that all shiner collections had FFCI values above the Wildlife Risk Level of 1.

Although PAH - enriched sediments were found in the Trenton Channel (Furlong et al., 1988), shiners from Sturgeon Bar had no measurable PAH residues. Low concentrations of phenanthrene were found in the Amherstburg shiner samples (Appendix III).

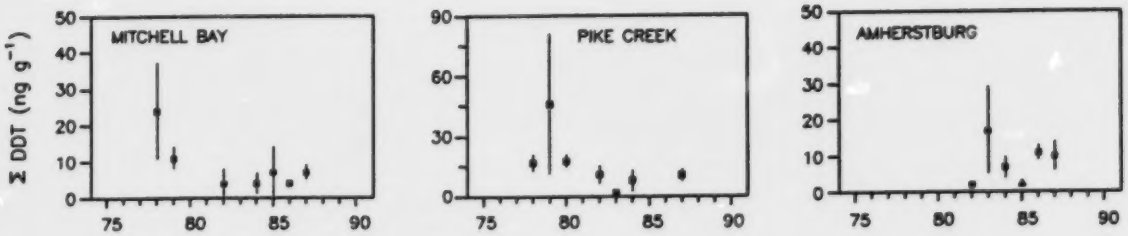
Low concentrations of chlordane were found in the Sturgeion Bar sample, while mirex, BHC, aldrin, heptachlor and toxaphene were not detected in any of the St. Clair and Detroit River collections.

Of the 7 sites sampled, only the Amherstburg collection had a large enough data base for temporal trend assessment. Changes in PCB and DDT residues were not significantly correlated ($p>0.05$) with time, whereas a significant decline in chlordane did occur ($p<0.05$; Figure 19).

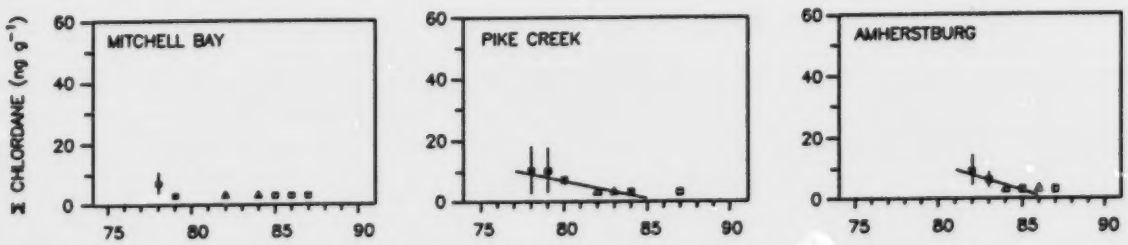
FIGURE 19: TEMPORAL TRENDS OF ΣPCB CONCENTRATIONS IN YOUNG-OF-THE-YEAR SPOTTAIL SHINERS FROM LAKE ST. CLAIR AND THE DETROIT RIVER. VALUES ARE MEANS +/- 95% CONFIDENCE LIMITS. SIGNIFICANT CORRELATIONS WITH TIME (P<0.5) ARE INDICATED WITH A STRAIGHT LINE.



TEMPORAL TRENDS OF Σ DDT CONCENTRATIONS IN YOUNG-OF-THE-YEAR SPOTTAIL SHINERS FROM LAKE ST. CLAIR AND THE DETROIT RIVER. VALUES ARE MEANS +/- 95% CONFIDENCE LIMITS. SIGNIFICANT CORRELATIONS WITH TIME (P<0.5) ARE INDICATED WITH A STRAIGHT LINE.



TEMPORAL TRENDS OF Σ CHLORDANE CONCENTRATIONS IN YOUNG-OF-THE-YEAR SPOTTAIL SHINERS FROM LAKE ST. CLAIR AND THE DETROIT RIVER. VALUES ARE MEANS +/- CONFIDENCE LIMITS. SIGNIFICANT CORRELATIONS WITH TIME (P<0.5) ARE INDICATED WITH A STRAIGHT LINE.



□ - NOT DETECTED
△ - TRACE AMOUNT

LAKE ST. CLAIR

Significant differences (ANOVA; $F = 26.6$; $p<0.05$) of total PCB concentrations were found at the 4 collection sites (Figure 20, Appendix V). In contrast to contaminant concentrations in the St. Clair River collections, Lake St. Clair shiners had relatively low contaminant levels (Figure 17). The highest PCB concentrations were found in the Pike Creek and Mitchell Bay shiners and the lowest at Chenal Ecarté and Thames River. These results show that PCB inputs via Chenal Ecarté were negligible. Collection sites at Pike Creek and Mitchell Bay, with the higher PCB residues, were likely influenced by discharges from the Middle, South and Johnson Channels.

Differences between the mean concentrations of total DDT were significant (ANOVA; $F = 4.9$; $p<0.05$), and the spatial patterns of DDT residues were similar to PCBs.

Differences between concentrations of hexachlorobenzene were significant (ANOVA; $F = 67.1$; $p<0.05$) at the Lake St. Clair sites sampled. The highest HCB concentrations were found in shiners from Chenal Ecarte and the lowest at Thames River (Figure 20). Significant differences (ANOVA; $F = 18.1$; $p<0.05$) were also found

FIGURE 20: SITE-SPECIFIC COMPARISON OF PCB RESIDUES (ng/g) IN YOUNG-OF-THE-YEAR SPOTTAIL SHINERS FROM LAKE ST.CLAIR FOR THE MOST RECENT YEAR,1986, 1987 OR 1988, USING TUKEY'S MULTIPLE RANGE TEST (95% CONFIDENCE LIMITS) ON LOG LOG TRANSFORMED DATA. (· ND = NOT DETECTED).

SITE	MEAN [PCB]	HOMOGENOUS GROUPS
CHENAL ECARTE	ND	□
THAMES RIVER	ND	□
MITCHELL BAY	40	■
PIKE CREEK	40	■

SITE-SPECIFIC COMPARISON OF DDT RESIDUES (ng/g) IN YOUNG-OF-THE-YEAR SPOTTAIL SHINERS FROM LAKE ST.CLAIR FOR THE MOST RECENT YEAR,1986, 1987 OR 1988, USING TUKEY'S MULTIPLE RANGE TEST (95% CONFIDENCE LIMITS) ON LOG LOG TRANSFORMED DATA.

SITE	MEAN [DDT]	HOMOGENOUS GROUPS
CHENAL ECARTE	6	□
THAMES RIVER	5	□ ■
MITCHELL BAY	7	□ ■
PIKE CREEK	14	■

SITE-SPECIFIC COMPARISON OF HCB RESIDUES (ng/g) IN YOUNG-OF-THE-YEAR SPOTTAIL SHINERS FROM LAKE ST.CLAIR FOR THE MOST RECENT YEAR,1986, 1987 OR 1988, USING TUKEY'S MULTIPLE RANGE TEST (95% CONFIDENCE LIMITS) ON LOG LOG TRANSFORMED DATA. (T = TRACE).

SITE	MEAN [HCB]	HOMOGENOUS GROUPS
THAMES RIVER	TR	□
MITCHELL BAY	2	▒
PIKE CREEK	3	▒
CHENAL ECARTE	6	■

SITE-SPECIFIC COMPARISON OF OCS RESIDUES (ng/g) IN YOUNG-OF-THE-YEAR SPOTTAIL SHINERS FROM LAKE ST.CLAIR FOR THE MOST RECENT YEAR,1986, 1987 OR 1988, USING TUKEY'S MULTIPLE RANGE TEST (95% CONFIDENCE LIMITS) ON LOG LOG TRANSFORMED DATA.

SITE	MEAN [OCS]	HOMOGENOUS GROUPS
THAMES RIVER	2	□
MITCHELL BAY	5	▒
PIKE CREEK	5	▒
CHENAL ECARTE	18	■

for octachlorostyrene. The highest OCS concentrations were found at Chenal Ecarté and the lowest at Thames River. These results suggest that the St. Clair River is a source of OCS and HCB. Contaminant levels in Lake St. Clair shiners were much lower than those from the St. Clair River samples (Figure 17). The apparent reduction in contaminant availability in Lake St. Clair is likely influenced by the extensive marsh system in the St. Clair River Delta (Hebert et al., 1990). Approximately 17,000 ha of wetlands span the international boundaries at the St. Clair River/Lake St. Clair confluence (Edsall et al., 1988) providing a depositional area for contaminated sediments.

Although PCBs, DDT, OCS, HCB and chlordane were found at most of the sampling sites, none of the collections had contaminant concentrations in excess of the Wildlife Protection Guidelines or Objectives.

Octachlorostyrene was one of the principal contaminants in shiners, and it raised the Forge Fish Contaminant Index considerably in 3 of the 4 Lake St. Clair collections (Figure 17). OCS contribution was especially prominent in the Chenal Ecarté sample, where the FFCI value nearly exceeded the Wildlife Risk Level.

Of 17 PAH compounds analyzed only phenanthrene (86 ng/g) was found in Mitchell's Bay shiners (Appendix III). Mirex, BHC, heptachlor, aldrin and toxaphene were not detected.

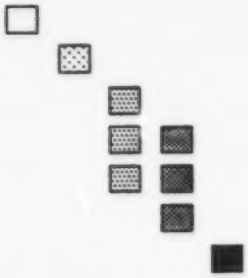
Of the four sites sampled, only Michell's Bay and Pike Creek collections had a large enough data base for temporal trend assessment. Changes in contaminant concentrations were not significantly correlated ($p>0.05$) with time for total PCBs and DDT (Figure 19). Chlordane concentrations decreased significantly ($p<0.05$) over time in the Pike Creek collections, but did not ($p>0.05$) in Mitchell's Bay.

LAKE ERIE

Differences between the mean concentrations of total PCB at 7 Lake Erie sites sampled were significant (ANOVA; $F = 73.3$; $p<0.05$). The highest PCB concentration was found in the Wheatley collections, from western Lake Erie and the lowest at Thunder Bay Beach (Figure 21). Generally, most of the shiner samples from eastern Lake Erie had lower PCB concentrations (Figure 22; Appendix V). The exception was the Port Dover collection. Total PCB concentrations in the Port Dover shiners were elevated relative to other eastern Lake Erie collections. Findings from this survey indicate that PCB availability was also elevated in the nearshore waters off Wheatley Harbour. Sediment surveys have identified PCB-contaminated sediments in Wheatley Harbour (IJC, 1989). The reasons for PCB enrichment of the nearshore water at Port Dover are not known.

Significant differences (ANOVA; $F = 6.9$; $p<0.05$) of total DDT concentrations were found at the 7 Lake Erie sites. The highest DDT concentrations were found in the Port Dover and Wheatley collections (Figures 21 & 22). The availability of DDT at Port Dover may be related to drainage from the tobacco fields of Simcoe County. The use of DDT as a pesticide for tobacco was continued after the general DDT ban in mid-1970's in the Province. Both Wheatley and Port Dover shiners contained the DDT

FIGURE 21: SITE-SPECIFIC COMPARISON OF PCB RESIDUES (ng/g) IN YOUNG-OF-THE-YEAR SPOTTAIL SHINERS FROM LAKE ERIE FOR THE MOST RECENT YEAR, 1986, 1987 OR 1988, USING TUKEY'S MULTIPLE RANGE TEST (95% CONFIDENCE LIMITS) ON LOG TRANSFORMED DATA. (ND = NOT DETECTED).

SITE	MEAN [PCB]	HOMOGENOUS GROUPS
THUNDER BAY BEACH	ND	
GRAND RIVER	26	
CENTRE CREEK	70	
BIG CREEK	95	
LEAMINGTON	116	
PORT DOVER	143	
WHEATLEY	385	

SITE-SPECIFIC COMPARISON OF DDT RESIDUES (ng/g) IN YOUNG-OF-THE-YEAR SPOTTAIL SHINERS FROM LAKE ERIE FOR THE MOST RECENT YEAR, 1986, 1987 OR 1988, USING TUKEY'S MULTIPLE RANGE TEST (95% CONFIDENCE LIMITS) ON LOG TRANSFORMED DATA.

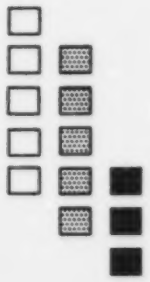
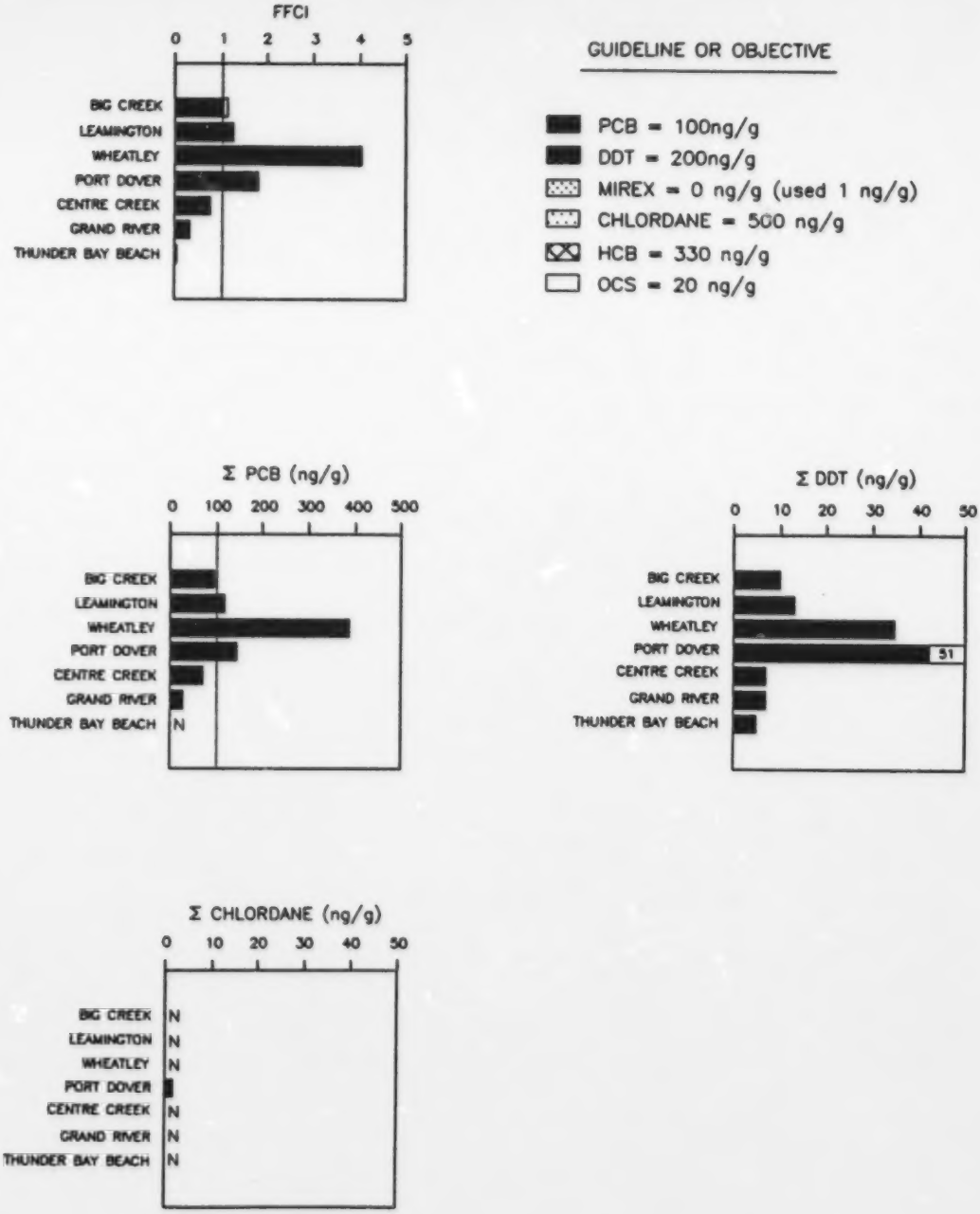
SITE	MEAN [DDT]	HOMOGENOUS GROUPS
THUNDER BAY BEACH	5	
CENTRE CREEK	7	
GRAND RIVER	7	
BIG CREEK	10	
LEAMINGTON	13	
WHEATLEY	36	
PORT DOVER	51	

FIGURE 22: LAKE ERIE FORAGE FISH CONTAMINANT INDEX (FFCI) FORCONTAMINANTS WITH WILDLIFE PROTECTION GUIDELINES OR OBJECTIVES. VALUES ARE THE SUM OF MEASURED CONCENTRATIONS IN YOY SPOTTAIL SHINERS (MOST RECENT YEAR, 1986, 1987 OR 1988) DIVIDED BY THE GUIDELINE FOR EACH CONTAMINANT. WILDLIFE RISK LEVEL = 1. (N = NOT DETECTED).



metabolites p,p'DDE and p,p'DDD. This observation was consistent with total DDT residues found at other Great Lakes sites with elevated DDT concentrations.

Low concentrations of chlordane, HCB and OCS were present in some of the Lake Erie collections, whereas BHC, heptachlor, aldrin and toxaphene were not detected.

PCB was the only compound in the Lake Erie collections that exceeded the Wildlife Protection Guideline. Total PCB concentrations in 3 of 7 (43%) Lake Erie shiner collections exceeded the IJC Aquatic Life Guideline of 100 ng/g (Figure 22). Although total PCB was the principal contaminant in Lake Erie shiner samples, contributions from OCS in the Big Creek collections raised the Forage Fish Contaminant Index above the Wildlife Risk Level. As a result of PCB, DDT and OCS residues, 4 of 7 (57%) of the Lake Erie shiner collections exceeded the Wildlife Risk Level (Figure 22).

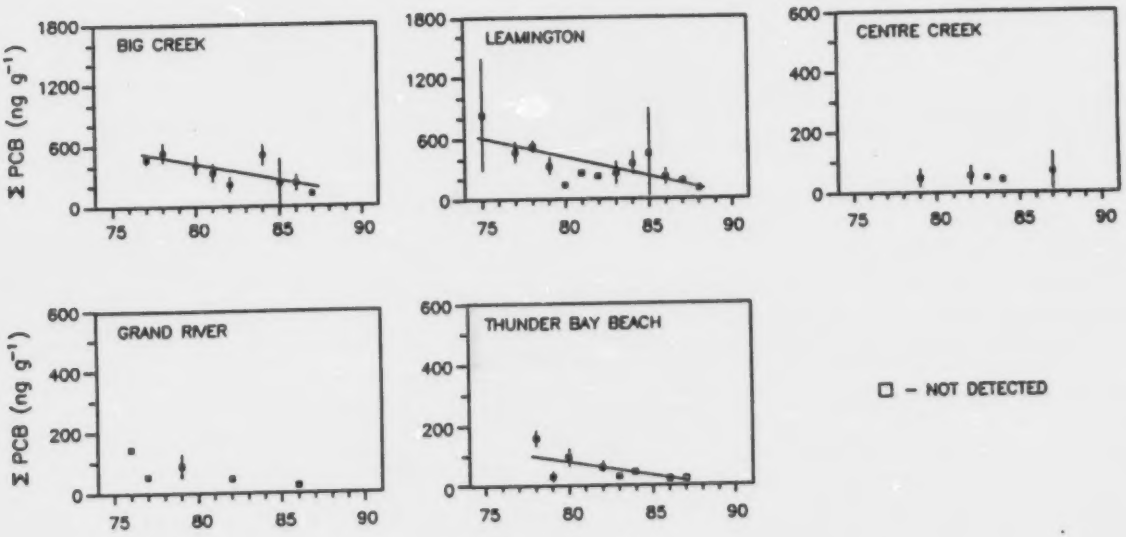
No PAH residues were found in the one Lake Erie sample analyzed from Port Stanley (Appendix III).

Total PCB, DDT and chlordane concentrations in recent shiner collections were significantly ($p<0.05$) lower than those in the earlier collections from mid-1970's (Appendix II). Total PCB and DDT residue declines in shiners decreased significantly ($p<0.05$)

over time in the Big Creek, Leamington and Thunder Bay Beach collections, while Centre Creek and Grand River collections did not change over time (Figure 23). Changes in chlordane residues were not significantly correlated ($p>0.05$) with time in any of the Lake Erie shiner collections (Figure 24). Although PCB and DDT concentrations in shiners continued to decrease at some sites during the 1980's, these reductions were moderate in comparison to changes during the late 1970's.

In comparison, other monitoring programs have shown similar trend results. Total PCB concentrations in herring gull eggs from the Middle Island colony in western Lake Erie have decreased since the early 1980's, except for the 1988 collection, when PCB concentrations increased (IJC, 1989). Contaminant surveillance program using a specific age class (4 +) yellow walleye (Stizestedion Vitreum) has shown a similar downward trend. However, after a period of steady decline from 1978, PCB concentrations in walleye increased during the period from 1985 - 1987 (IJC, 1989). Although these trends are in general agreement with spottail shiner data from western Lake Erie, direct comparison should be avoided, because of the differences in habitat utilization.

FIGURE 23: TEMPORAL TRENDS OF Σ PCB CONCENTRATIONS IN YOUNG-OF-THE-YEAR SPOTTAIL SHINERS FROM LAKE ERIE. VALUES ARE MEANS +/- 95% CONFIDENCE LIMITS. SIGNIFICANT CORRELATIONS WITH TIME (P<0.05) ARE INDICATED WITH A STRAIGHT LINE.



TEMPORAL TRENDS OF Σ DDT CONCENTRATIONS IN YOUNG-OF-THE-YEAR SPOTTAIL SHINERS FROM LAKE ERIE. VALUES ARE MEANS +/- 95% CONFIDENCE LIMITS. SIGNIFICANT CORRELATIONS WITH TIME (P<0.05) ARE INDICATED WITH A STRAIGHT LINE.

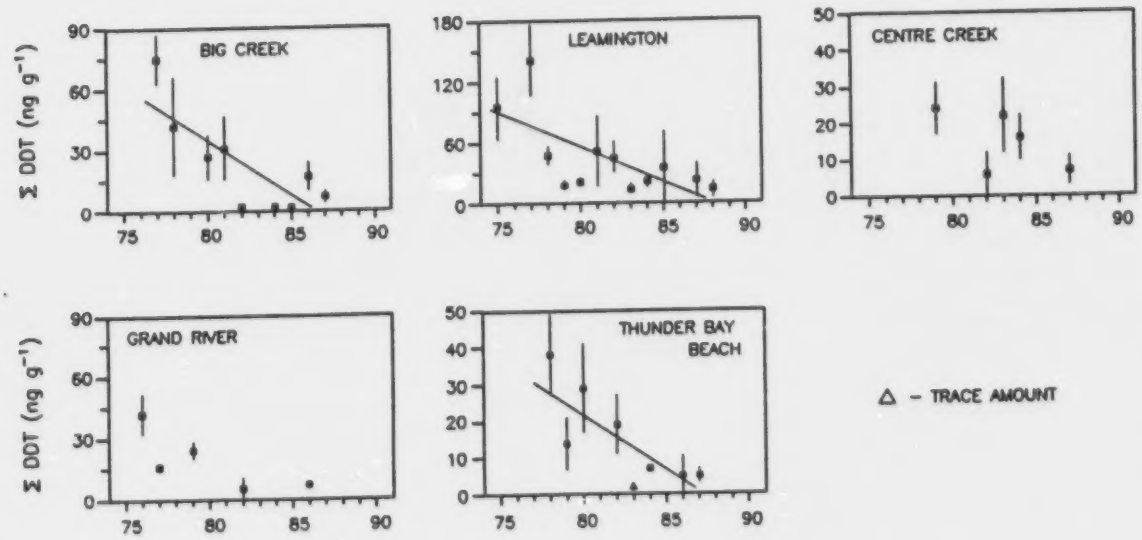
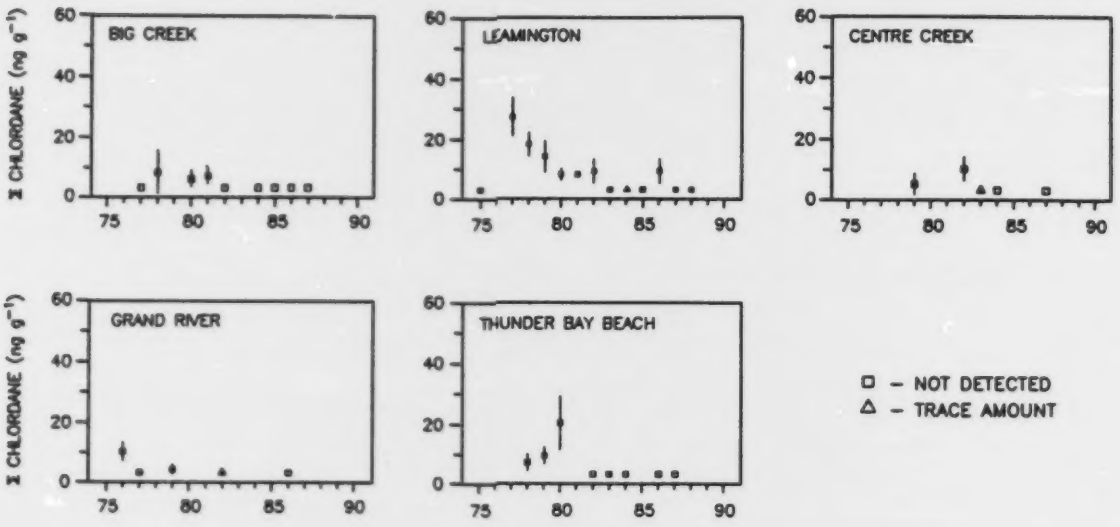


FIGURE 24: TEMPORAL TRENDS OF Σ CHLORDANE CONCENTRATIONS IN YOUNG-OF-THE-YEAR SPOTTAIL SHINERS FROM LAKE ERIE. VALUES ARE MEANS +/- 95% CONFIDENCE LIMITS. SIGNIFICANT CORRELATIONS WITH TIME (P<0.05) ARE INDICATED WITH A STRAIGHT LINE.



NIAGARA RIVER

Differences between the mean concentrations of total PCBs at 7 Niagara River sites sampled were significant (ANOVA; $F = 28.1$; $p<0.05$). The highest PCB concentration was found in samples from the 102nd Street in Niagara Falls, N.Y., and the lowest at Usher's Creek (Figures 25 & 26). PCB concentrations were generally higher in shiner collections from the New York shoreline (Appendices II and VI).

Mean concentrations of total DDT were also significantly different (ANOVA; $F = 3.8$; $p<0.05$) at the 7 Niagara River sites sampled. The highest total DDT concentrations were found in the Niagara-on-the-Lake shiners and the lowest in Wheatfield (Figure 26).

Significantly different (ANOVA; $F = 57.6$; $p<0.05$) HCB concentrations were also found (Figure 27). The highest concentrations were in the 102nd Street collections and the lowest in Fort Erie (Figure 26). Unusually high concentrations of tetra and pentachlorobenzene (365 ng/g) were found in shiners from the 102nd Street collections. These findings are in agreement with the results from caged mussels studies in 1987. Elevated concentrations of tetra, penta and hexachlorobenzenes

FIGURE 25: SITE-SPECIFIC COMPARISON OF PCB RESIDUES (ng/g) IN YOUNG-OF-THE-YEAR SPOTTAIL SHINERS FROM THE NIAGARA RIVER FOR THE MOST YEAR, 1986, 1987 OR 1988, USING TUKEY'S MULTIPLE RANGE TEST (95% CONFIDENCE LIMITS) ON LOG TRANSFORMED DATA.

SITE	MEAN [PCB]	HOMOGENOUS GROUPS
USHERS CREEK	10	
FORT ERIE	34	
WHEATFIELD, N.Y.	86	
LEWISTON, N.Y.	99	
PEGGY'S EDDY, N.Y.	133	
NIAGARA-ON-THE-LAKE	145	
102nd STREET, N.Y.	172	

SITE-SPECIFIC COMPARISON OF DDT RESIDUES (ng/g) IN YOUNG-OF-THE-YEAR SPOTTAIL SHINERS FROM THE NIAGARA RIVER FOR THE MOST YEAR, 1986, 1987 OR 1988, USING TUKEY'S MULTIPLE RANGE TEST (95% CONFIDENCE LIMITS) ON LOG TRANSFORMED DATA.

SITE	MEAN [DDT]	HOMOGENOUS GROUPS
102nd STREET, N.Y.	7	
WHEATFIELD, N.Y.	6	
LEWISTON, N.Y.	14	
USHER'S CREEK	16	
FORT ERIE	19	
PEGGY'S EDDY, N.Y.	23	
NIAGARA-ON-THE-LAKE	47	

FIGURE 26: NIAGARA RIVER FORAGE FISH CONTAMINANT INDEX (FFCI) FOR CONTAMINANTS WITH WILDLIFE PROTECTION GUIDELINES OR OBJECTIVES. VALUES ARE THE SUM OF MEASURED CONCENTRATIONS IN YOY SPOTTAIL SHINERS (MOST RECENT YEAR, 1986, 1987 OR 1988) DIVIDED BY THE GUIDELINE FOR EACH CONTAMINANT. WILDLIFE RISK LEVEL = 1. (N = NOT DETECTED, T = TRACE).

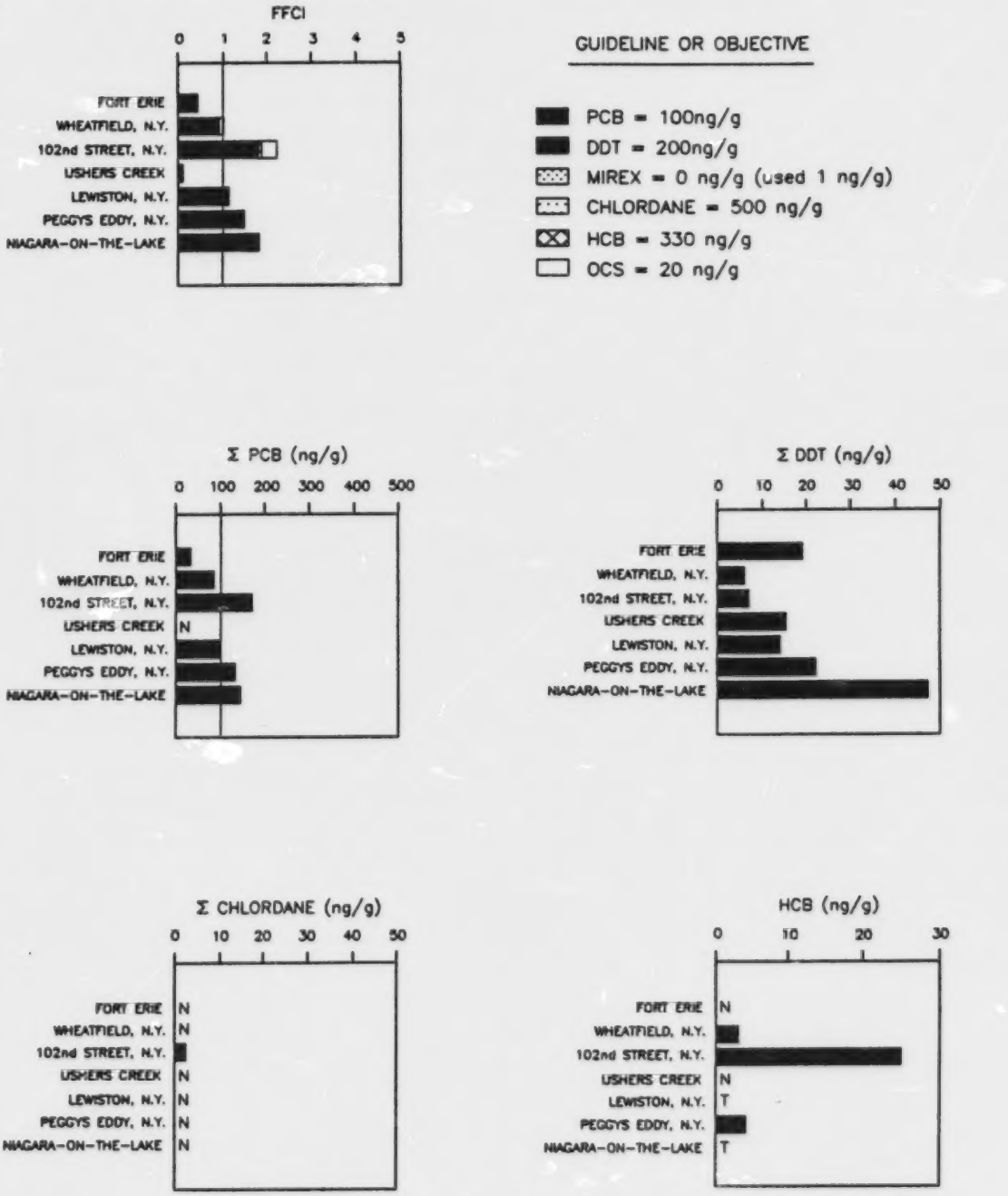


FIGURE 27: SITE-SPECIFIC COMPARISON OF HCB RESIDUES (ng/g) IN YOUNG-OF-THE-YEAR SPOTTAIL SHINERS FROM THE NIAGARA RIVER FOR THE MOST YEAR, 1986, 1987 OR 1988, USING TUKEY'S MULTIPLE RANGE TEST (95% CONFIDENCE LIMITS) ON LOG TRANSFORMED DATA. (ND = NOT DETECTED; TR = TRACE).

SITE	MEAN [HCB]	HOMOGENOUS GROUPS
FORT ERIE	ND	
USHERS CREEK	ND	
LEWISTON, N.Y.	TR	
NIAGARA-ON-THE-LAKE	1	
WHEATFIELD, N.Y.	3	
PEGGY'S EDDY, N.Y.	4	
102nd STREET, N.Y.	25	

SITE-SPECIFIC COMPARISON OF OCS RESIDUES (ng/g) IN YOUNG-OF-THE-YEAR SPOTTAIL SHINERS FROM THE NIAGARA RIVER FOR THE MOST YEAR, 1986, 1987 OR 1988, USING TUKEY'S MULTIPLE RANGE TEST (95% CONFIDENCE LIMITS) ON LOG TRANSFORMED DATA. (ND = NOT DETECTED; TR = TRACE).

SITE	MEAN [OCS]	HOMOGENOUS GROUPS
FORT ERIE	ND	
USHER'S CREEK	ND	
PEGGY'S EDDY, N.Y.	ND	
LEWISTON, N.Y.	TR	
WHEATFIELD, N.Y.	2	
NIAGARA-ON-THE-LAKE	2	
102nd STREET, N.Y.	7	

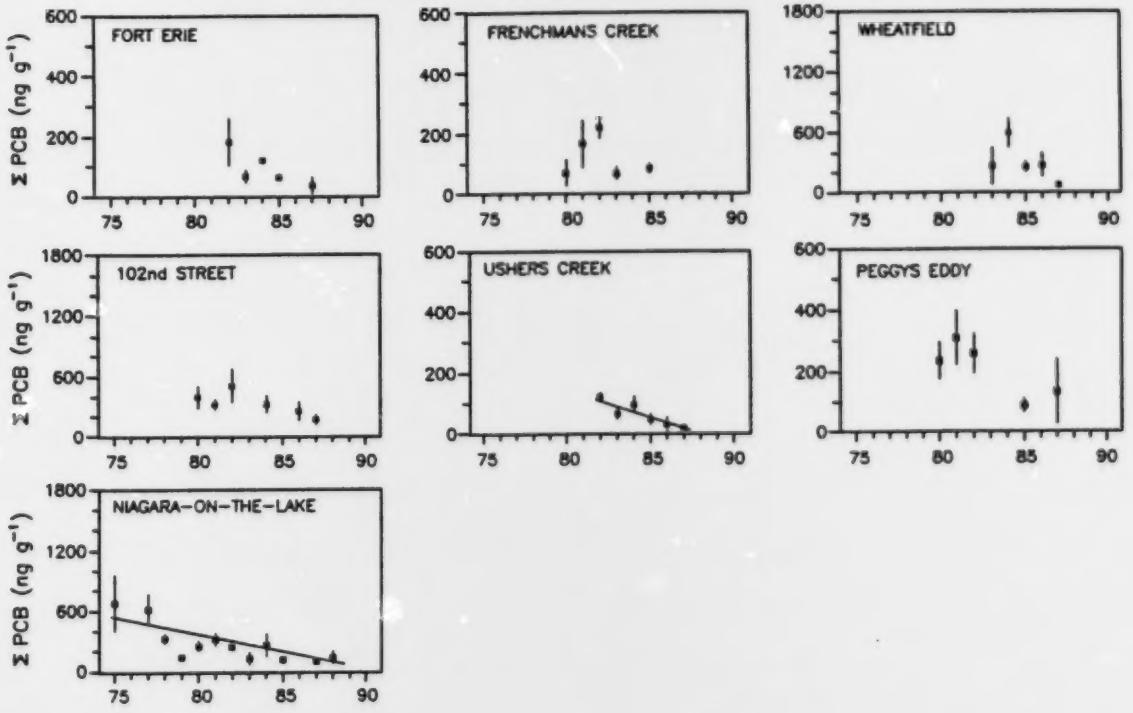
were found in caged mussels at the 102nd Street sewer (OMOE unpublished data). Work by Elder et al. (1981) has shown that chlorobenzenes were part of the chemical wastes stored at the Hooker chemical disposal site at Love Canal, near the 102nd Street collection site. Results from the shiner survey and caged mussels suggest that leachate from the Love Canal disposal site continues to reach Niagara River. The spatial distribution pattern of mirex in shiner collections from the Niagara River provides further support to the above conclusion. Mirex residue data from shiner collections over a 7 year period (1980 - 1987) indicate that the 102nd Street is the uppermost site in the Niagara River where bioavailable mirex exists (Appendix II). Results from sediment surveys are in agreement with the shiner data (NRTC, 1984). Mirex was not detected in the most recent shiner samples from the Niagara River, and its presence in shiners from Niagara River and Lake Ontario has been intermittent. Although the OCS concentrations were low, significant differences (ANOVA; $F = 3.8$; $p<0.05$) were found at the 7 Niagara River sites (Figure 27). The highest OC5 concentration was found in shiners from the 102nd Street site and the lowest from Fort Erie.

Low concentrations of chlordane and BHC were found in samples from the 102nd Street, whereas heptachlor, aldrin and toxaphene were not detected in any of the recent shiner samples from the Niagara River.

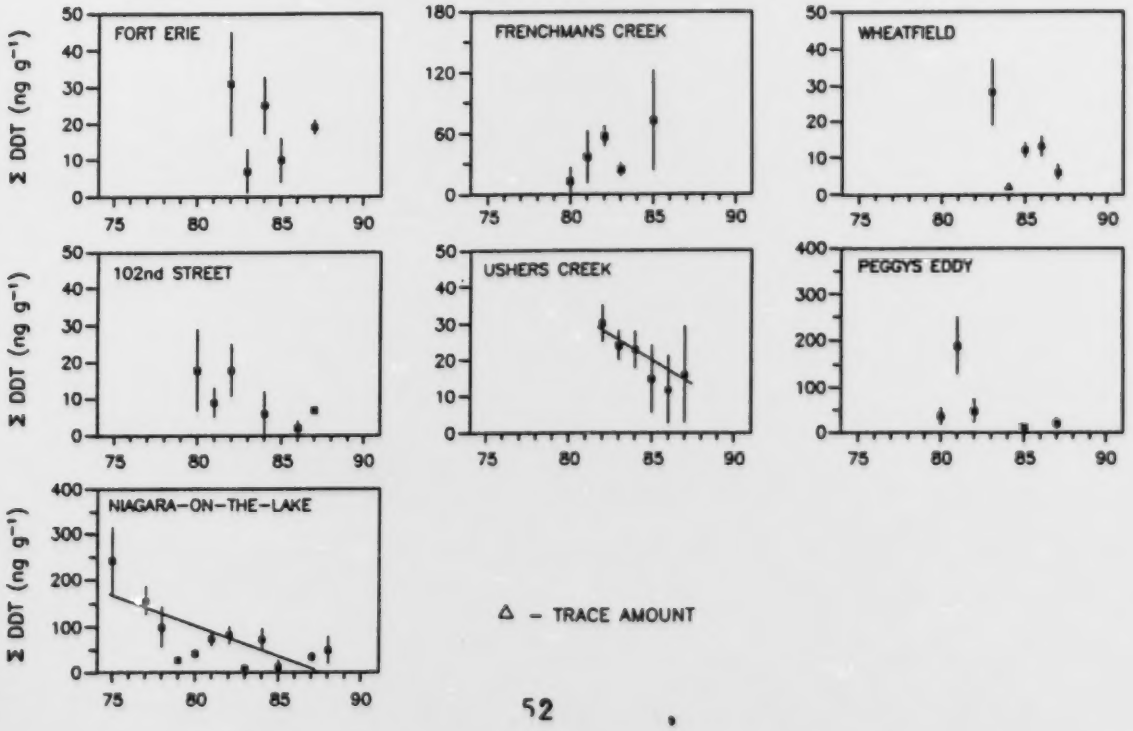
Total PCB concentrations exceeded the IJC Aquatic Life Guideline of 100 ng/g in 3 of 7 (43%) Niagara River shiner collections (Figure 26). PCBs were the principal contaminant in the Niagara River collections. However, contributions from DDT raised the Forage Fish Contaminant Index above the Wildlife Risk Level in the Wheatfield and Lewiston samples. As a result of PCB, DDT and OCS, 5 of 7 (71%) of the Niagara River shiner collections exceeded the Wildlife Risk Level (Figure 26).

Total PCB and total DDT residues in Usher's Creek and Niagara-on-the-Lake collections decreased significantly ($p<0.05$) over time, whereas residues in the remaining Niagara River collections did not (Figure 28). Chlordane and mirex residues in Peggy's Eddy collections also decreased significantly ($p<0.05$) over time (Figure 29). However, since mirex concentrations in the majority of samples were near their detection limits, quantitative assessment of the data was impaired.

FIGURE 28: TEMPORAL TRENDS OF Σ PCB CONCENTRATIONS IN YOUNG-OF-THE-YEAR SPOTTAIL SHINERS FROM THE NIAGARA RIVER. VALUES ARE MEANS +/- 95% CONFIDENCE LIMITS. SIGNIFICANT CORRELATIONS WITH TIME (P<0.05) ARE INDICATED WITH A STRAIGHT LINE.

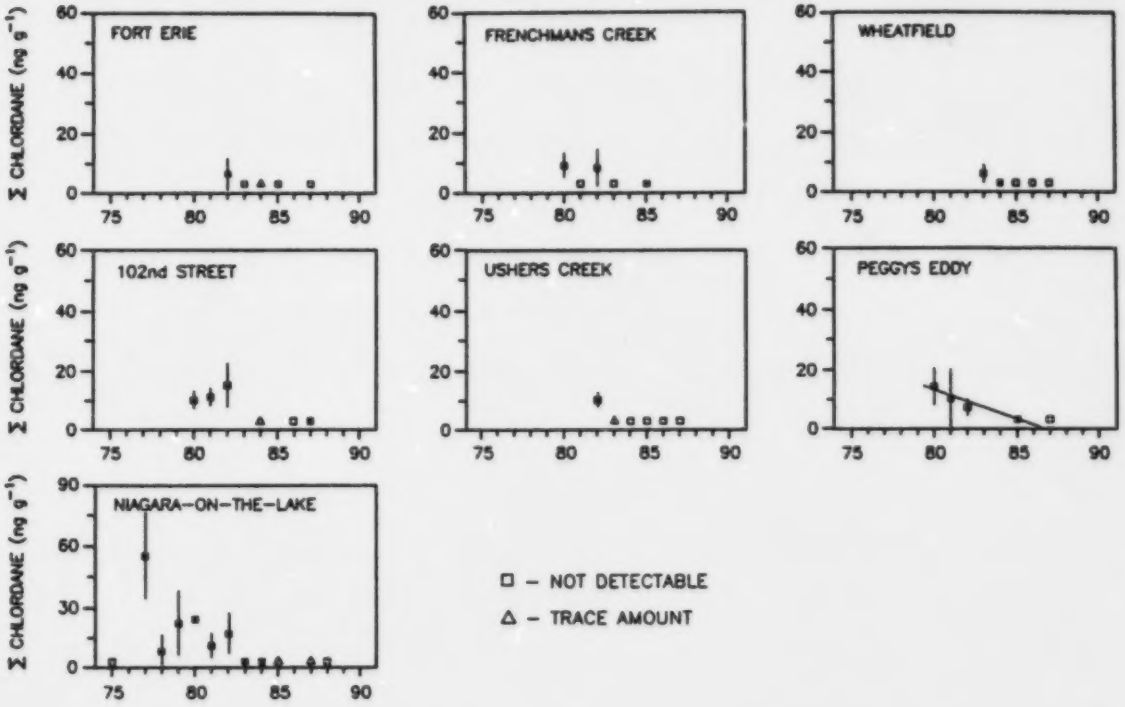


TEMPORAL TRENDS OF Σ DDT CONCENTRATIONS IN YOUNG-OF-THE-YEAR SPOTTAIL SHINERS FROM THE NIAGARA RIVER. VALUES ARE MEANS +/- 95% CONFIDENCE LIMITS. SIGNIFICANT CORRELATIONS WITH TIME (P<0.05) ARE INDICATED WITH A STRAIGHT LINE.

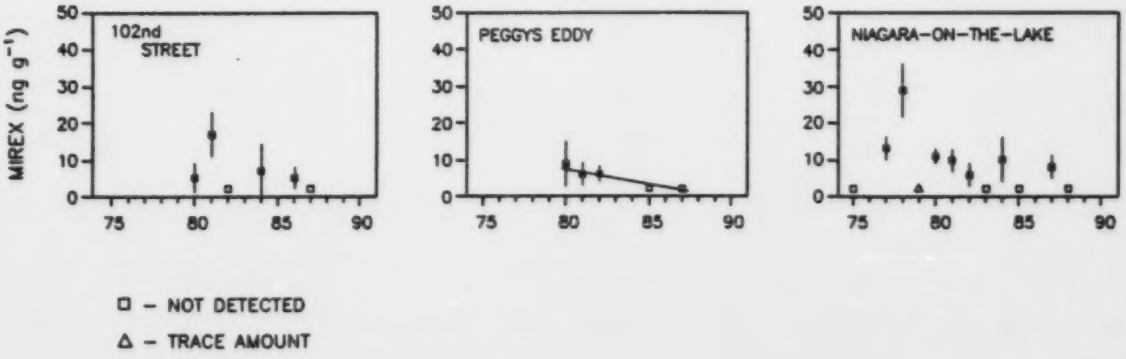


Δ - TRACE AMOUNT

FIGURE 29: TEMPORAL TRENDS OF Σ CHLORDANE CONCENTRATIONS IN YOUNG-OF-THE-YEAR SPOTTAIL SHINERS FROM THE NIAGARA RIVER. VALUES ARE MEANS +/- 95% CONFIDENCE LIMITS. SIGNIFICANT TRENDS WITH TIME (P<0.05) ARE INDICATED WITH A STRAIGHT LINE.



TEMPORAL TRENDS OF MIREX CONCENTRATIONS IN YOUNG-OF-THE-YEAR SPOTTAIL SHINERS FROM THE NIAGARA RIVER. VALUES ARE MEANS +/- 95% CONFIDENCE LIMITS. SIGNIFICANT CORRELATIONS WITH TIME (P<0.05) ARE INDICATED WITH A STRAIGHT LINE.



LAKE ONTARIO

Differences between the mean concentration of total PCBs at 14 Lake Ontario sites sampled were significant (ANOVA; $F = 46.0$; $p<0.05$). The highest PCB concentration was found in shiners collected at the Credit River, and the lowest at Bluffer's Park (Figure 30). PCB concentrations in samples from eastern Lake Ontario were generally lower than those from western Lake Ontario (Figure 31; Appendix VII). While the atmosphere may be an important source of PCBs, with estimates ranging from 180 - 300 kg/yr, (Thomann and DiToro, 1983; Eisenreich et al., 1981), there was no evidence from the nearshore shiner data that atmospheric inputs of PCBs play a major role. Since the spatial pattern of PCB residues in shiners was irregular, it may be concluded that individual watersheds governed PCB availability in nearshore waters (Appendix II).

Significant differences (ANOVA; $F = 25.2$; $p<0.05$) of total DDT concentrations were found at the 14 Lake Ontario sites sampled. The highest DDT concentration was found in shiners from Twelve Mile Creek and the lowest at Wolfe Island (Figure 30). Similar to PCB residues, higher total DDT concentrations were also found in shiners from western Lake Ontario. The metabolite p,p'DDE was the principal component of total DDT, generally comprising from 81% - 100% of the total DDT residue. These values are somewhat higher than data reported for the U.S., where

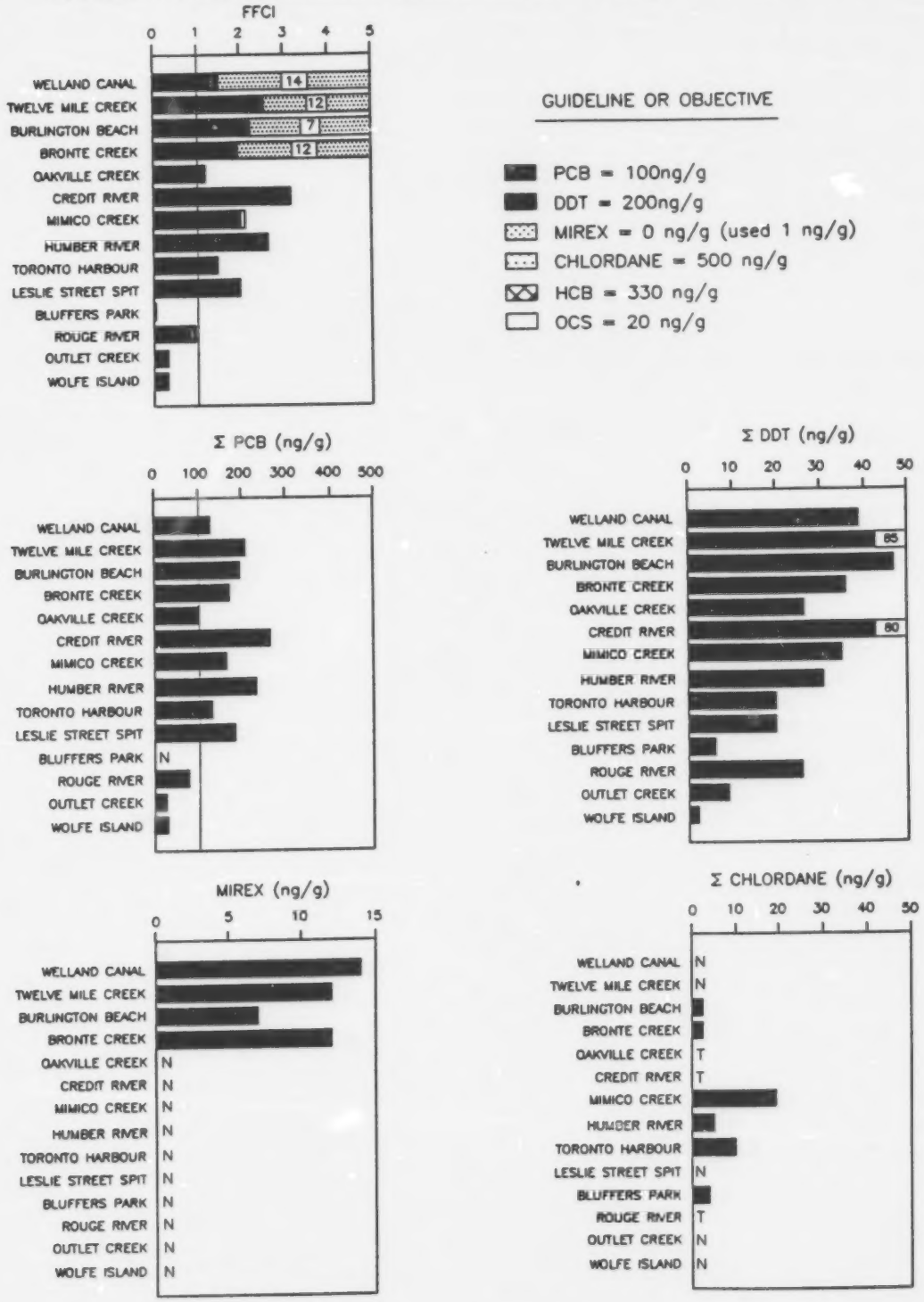
FIGURE 30: SITE-SPECIFIC COMPARISON OF PCB RESIDUES (ng/g) IN YOUNG-OF-THE-YEAR SPOTTAIL SHINERS FROM LAKE ONTARIO FOR THE MOST RECENT YEAR, 1986, 1987 OR 1988, USING TUKEY'S MULTIPLE RANGE TEST (95% CONFIDENCE LIMITS) ON LOG TRANSFORMED DATA. (ND = NOT DETECTED).

SITE	MEAN [PCB]	HOMOGENOUS GROUPS
BLUFFERS PARK	ND	
OUTLET RIVER	26	
WOLFE ISLAND	31	
ROUGE RIVER	78	
OAKVILLE CREEK	101	
WELLAND CANAL	127	
TORONTO HARBOUR	132	
BRONTE CREEK	171	
MIMICO CREEK	173	
LESLIE STREET SPIT	185	
BURLINGTON BEACH	194	
TWELVE MILE CREEK	207	
HUMBER RIVER	235	
CREDIT RIVER	264	

SITE-SPECIFIC COMPARISON OF DDT RESIDUES (ng/g) IN YOUNG-OF-THE-YEAR SPOTTAIL SHINERS FROM LAKE ONTARIO FOR THE MOST RECENT YEAR, 1986, 1987 OR 1988, USING TUKEY'S MULTIPLE RANGE TEST (95% CONFIDENCE LIMITS) ON LOG TRANSFORMED DATA.

SITE	MEAN [DDT]	HOMOGENOUS GROUPS
WOLFE ISLAND	2	
BLUFFERS PARK	6	
OUTLET PARK	9	
TORONTO HARBOUR	20	
LESLIE SPIT	20	
ROUGE RIVER	26	
OAKVILLE CREEK	28	
HUMBER RIVER	31	
MIMICO CREEK	35	
BRONTE CREEK	36	
WELLAND CANAL	39	
BURLINGTON BEACH	47	
CREDIT RIVER	80	
TWELVE MILE CREEK	85	

FIGURE 31: LAKE ONTARIO FORAGE FISH CONTAMINANT INDEX (FFCI) FOR CONTAMINANTS WITH WILDLIFE PROTECTION GUIDELINES OR OBJECTIVES. VALUES ARE THE SUM OF MEASURED CONCENTRATIONS IN YOY SPOTTAIL SHINERS (MOST RECENT YEAR, 1986, 1987 OR 1988) DIVIDED BY THE GUIDELINE FOR EACH CONTAMINANT. WILDLIFE RISK LEVEL = 1. (N = NOT DETECTED, T = TRACE).



p,p'DDE comprised about 70% of total DDT (Schmidt et al., 1985). Metabolite p,p'DDD was higher in the Mimico Creek, Humber River and Toronto Inner Harbour samples, contributing from 40% - 63% of the total DDT residue. The presence of p,p'DDD suggests recent use of DDT since p,p'DDD is less stable than p,p'DDE (Aguilar, 1984).

Significant differences were found in mirex concentrations at the 14 Lake Ontario sites sampled (ANOVA; $F = 111.8$; $p<0.05$). The highest mirex concentrations were clearly associated with the four collection sites in western Lake Ontario and mirex was not detected in any of the other most recent shiner collections (Figure 32). Historically, mirex concentrations in samples from western Lake Ontario have been found irregularly, and the spatial patterns support the assumption that the Niagara River is one of two sources of mirex to Lake Ontario (Pickett and Dossett, 1979). However, mirex residues in the 1987 collections were anomalous with unusually high concentrations in the Credit River and Wolfe Island shiners. Although low concentrations of mirex have been found in Wolfe Island shiners since 1982, presumably as a result of inputs from Oswego, N.Y. (Scrudato and Del Prete, 1982), reasons for the 1987 increases are not known. It may be noteworthy, however, that mirex was not detected in the 1988 Wolfe Island and Credit River shiner collections.

FIGURE 32: SITE-SPECIFIC COMPARISON OF CHLORDANE RESIDUES (ng/g) IN YOUNG-OF-THE-YEAR SPOTTAIL SHINERS FROM LAKE ONTARIO FOR THE MOST RECENT YEAR, 1986, 1987 OR 1988, USING TUKEY'S MULTIPLE RANGE TEST (95% CONFIDENCE LIMITS) ON LOG TRANSFORMED DATA. (ND = NOT DETECTED, TR = TRACE).

SITE	MEAN [CHLORDANE]	HOMOGENOUS GROUPS
OUTLET RIVER	ND	
TWELVE MILE CREEK	ND	
WELLAND CANAL	ND	
WOLFE ISLAND	ND	
CREDIT RIVER	TR	
LESLIE SPIT	TR	
OAKVILLE CREEK	TR	
ROUGE RIVER	TR	
BRONTE CREEK	2	
BURLINGTON BEACH	2	
BLUFFERS PARK	3	
TORONTO HARBOUR	4	
HUMBER RIVER	9	
MIMICO CREEK	19	

SITE-SPECIFIC COMPARISON OF MIREX RESIDUES (ng/g) IN YOUNG-OF-THE-YEAR SPOTTAIL SHINERS FROM LAKE ONTARIO FOR THE MOST RECENT YEAR, 1986, 1987 OR 1988, USING TUKEY'S MULTIPLE RANGE TEST (95% CONFIDENCE LIMITS) ON LOG TRANSFORMED DATA. (ND = NOT DETECTED).

SITE	MEAN [MIREX]	HOMOGENOUS GROUPS
BLUFFERS PARK	ND	
CREDIT RIVER	ND	
HUMBER RIVER	ND	
LESLIE SPIT	ND	
MIMICO CREEK	ND	
OAKVILLE CREEK	ND	
OUTLET RIVER	ND	
ROUGE RIVER	ND	
TORONTO HARBOUR	ND	
WOLFE ISLAND	ND	
BURLINGTON BEACH	7	
TWELVE MILE CREEK	12	
BRONTE CREEK	12	
WELLAND CANAL	14	

Total chlordane concentrations at 14 Lake Ontario shiner collection sites were significantly different (ANOVA; $F = 30.7$; $p<0.05$). The highest chlordane concentration was found in shiners from Mimico Creek, while chlordane was not detected in samples from the Outlet River, Wolfe Island, Welland Canal and Twelve Mile Creek (Figure 31).

Hexachlorobenzene, OCS, heptachlor, aldrin, toxaphene and BHC were generally found in low concentrations, or they were not detected.

PCB concentrations in 10 of 14 (71%) Lake Ontario collections exceeded the IJC Aquatic Life Guideline of 100 ng/g, and four of 14 (29%) shiner collections had mirex concentrations in excess of the IJC Aquatic Life Guideline (Figure 31). Although metabolites of DDT were found in all Lake Ontario shiner samples, total DDT concentrations were below the NYSDEC Fish Flesh Criterion of 200 ng/g. None of the other organochlorine residues exceeded the Criteria for Wildlife Protection (Appendix II).

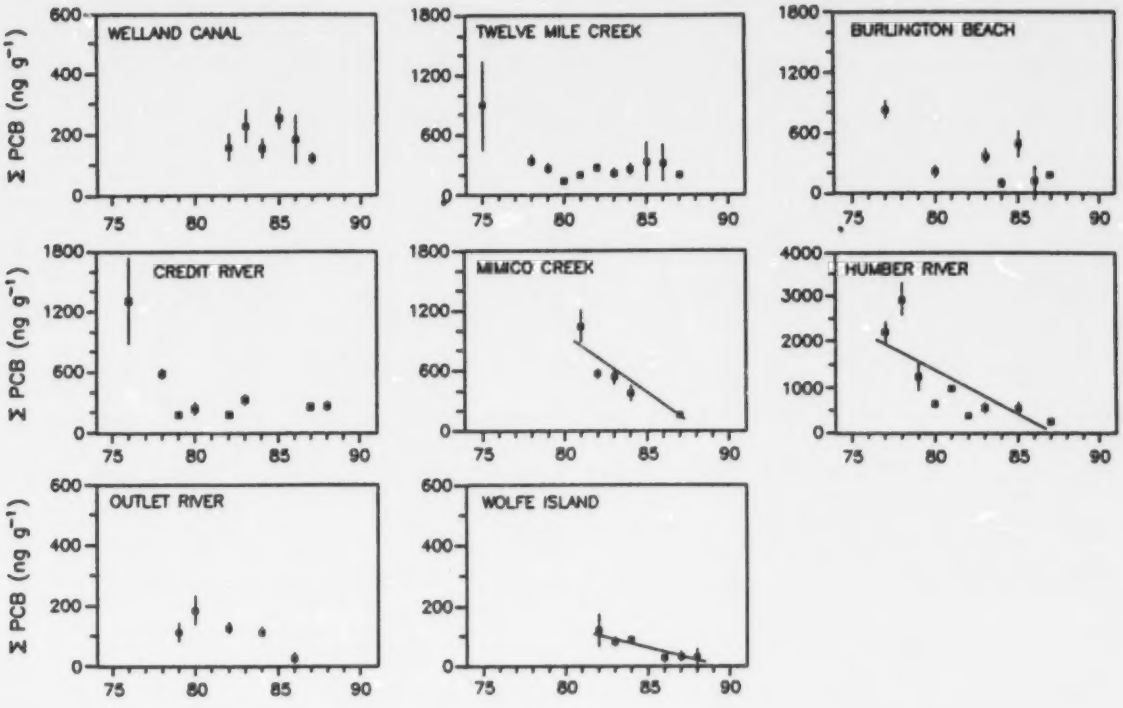
Contributions from DDT and mirex raised the Forage Fish Contaminant Index considerably in individual collections, particularly from western Lake Ontario sites. However, the number of Lake Ontario collections exceeding the Wildlife Risk Level remained the same as from individual compound assessments. Ten of 14 (71%) Lake Ontario shiner collections had Index values above the Wildlife Risk Level (Figure 31).

Shiners from the Humber Bay collection had 166 ng/g of PAH residues, while Burlington Beach and Oakville Creek samples had no quantifiable PAHs (Appendix III). No Guidelines or Objectives are available to assess the importance of PAH residue accumulations.

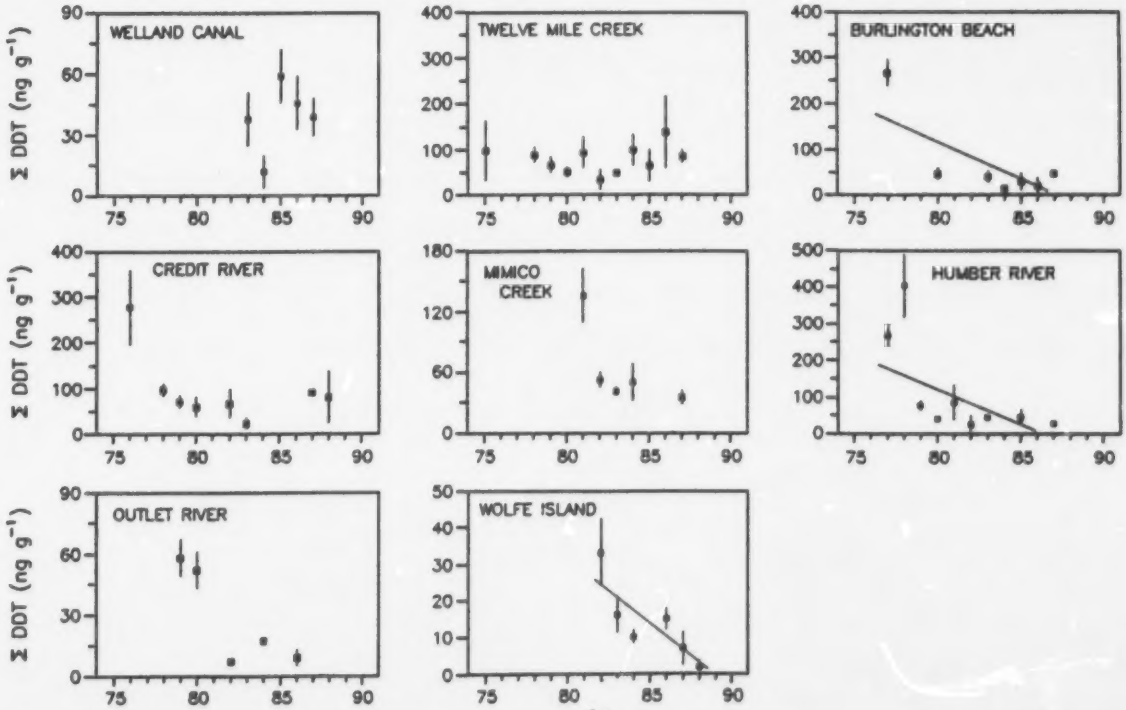
Total PCB, DDT and chlordane concentrations in the most recent (1986 - 1988) shiner samples from Lake Ontario were significantly ($p<0.05$; Student's t-test) lower than contaminant residues in shiners from the mid-1970's. These decreases in total DDT and PCBs during the late 1970's coincided with the ban of both chemicals by all Great Lakes jurisdictions. However, reductions in PCBs, DDT and chlordane have moderated during the 1980's, when compared to the massive declines during the late 1970's (Appendix II).

Of the 8 shiner collection sites selected for temporal trend assessment, PCB reductions were significantly correlated ($p<0.05$) with time at Mimico Creek, Humber River and Wolfe Island (Figure 33). It should be noted, however, that PCB residues in shiners tended to increase during the 1980's in the Centre Creek, Twelve Mile Creek and Credit River samples. Total DDT residues declined significantly ($p<0.05$) over time in the Burlington Beach, Humber River and Wolfe Island collections (Figure 33). There was a tendency towards increasing DDT residues in the Frenchman's Creek and Twelve Mile Creek samples during the 1980's. Total chlordane reductions were significantly correlated

FIGURE 33: TEMPORAL TRENDS OF Σ PCB CONCENTRATIONS IN YOUNG-OF-THE-YEAR SPOTTAIL SHINERS FROM LAKE ONTARIO. VALUES ARE MEANS +/- 95% CONFIDENCE LIMITS. SIGNIFICANT CORRELATIONS WITH TIME (P<0.05) ARE INDICATED WITH A STRAIGHT LINE.



TEMPORAL TRENDS OF Σ DDT CONCENTRATIONS IN YOUNG-OF-THE-YEAR SPOTTAIL SHINERS FROM LAKE ONTARIO. VALUES ARE MEANS +/- 95% CONFIDENCE LIMITS. SIGNIFICANT CORRELATIONS WITH TIME (P<0.05) ARE INDICATED WITH A STRAIGHT LINE.

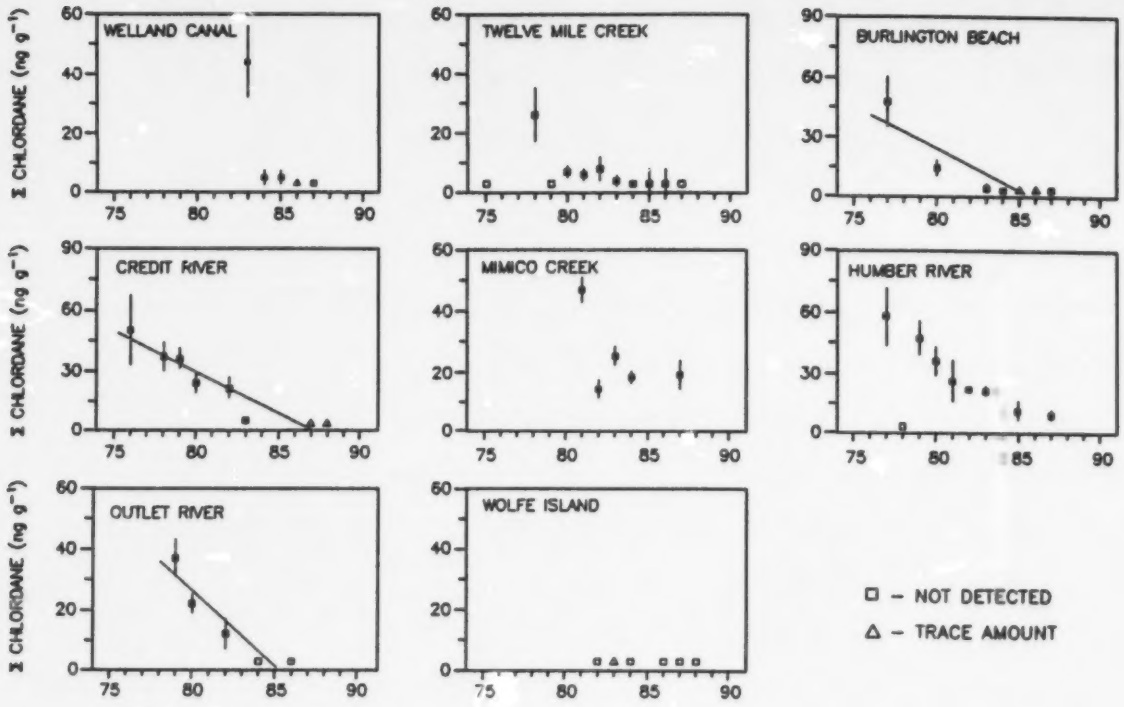


($p<0.05$) with time in the Burlington Beach, Credit River and Outlet River samples (Figure 34). Significant ($p<0.05$) chlordane declines over time were also found at Humber River, when excluding the anamolous residue values for 1978. Mirex concentrations in shiner collections from the late 1980's were generally less than mirex in samples from the 1970's and significant ($p<0.05$) residue declines over time were found only in the Outlet River collections (Figure 34). However, quantitative trend assessment was impaired by the fact that the majority of mirex values were near their detection limits and residue fluctuations were considerable.

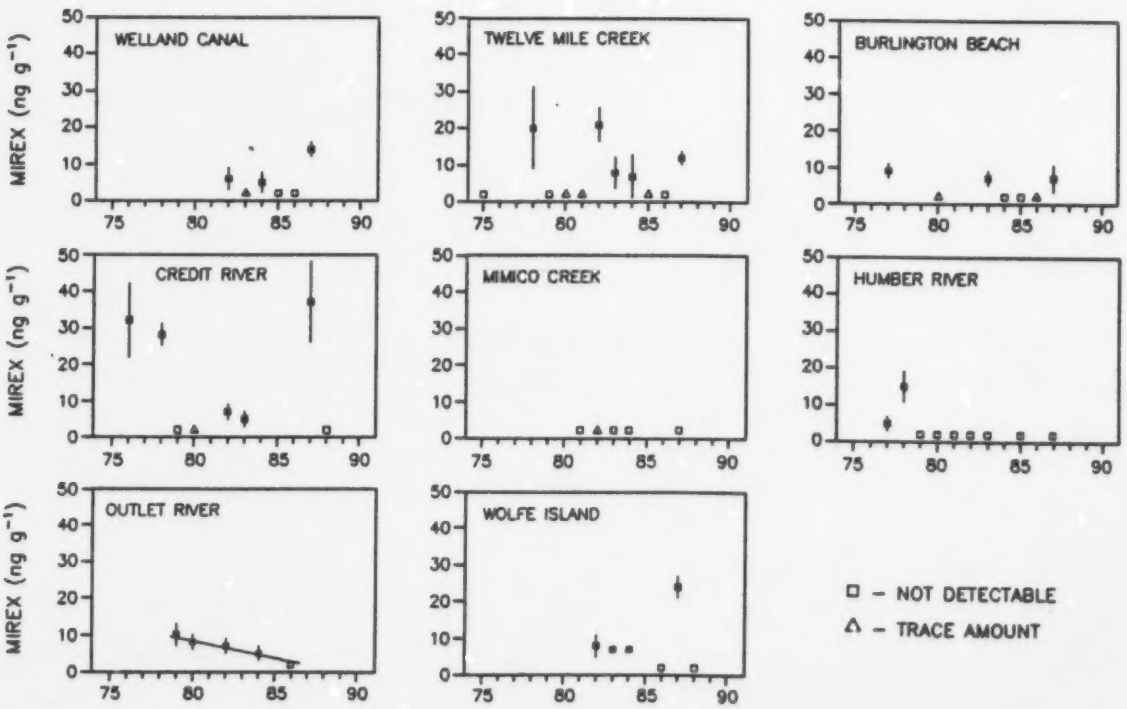
In comparison to monitoring programs based on open lake biota, nearshore spottail shiner data paralleled contaminant trends in Herring Gull eggs from Snake and Mugg's Islands. Herring gull egg data show that total PCB, p,p'DDE and mirex concentrations decreased throughout the 1980's (IJC, 1989).

PCB residue trends in whole, four-year-old (4+) lake trout (Salvelinus namaycush) from Lake Ontario differed from the nearshore shiner data. While PCBs in lake trout increased in 1987 (IJC, 1989), no marked increase was noted in most of the shiner collections (Appendix II). However, given that the nearshore shiner collections reflected site-specific conditions in contaminant availability, it is not surprising that contaminant trends varied in the wide-ranging lake trout.

FIGURE 34: TEMPORAL TRENDS OF Σ CHLORDANE CONCENTRATIONS IN YOUNG-OF-THE-YEAR SPOTTAIL SHINERS FROM LAKE ONTARIO. VALUES ARE MEANS +/- 95% CONFIDENCE LIMITS. SIGNIFICANT CORRELATIONS WITH TIME (P<0.05) ARE INDICATED WITH A STRAIGHT LINE.



TEMPORAL TRENDS OF MIREX CONCENTRATIONS IN YOUNG-OF-THE-YEAR SPOTTAIL SHINERS FROM LAKE ONTARIO. VALUES ARE MEANS +/- 95% CONFIDENCE LIMITS. SIGNIFICANT CORRELATIONS WITH TIME (P<0.05) ARE INDICATED WITH A STRAIGHT LINE.



Contaminant residue data from mixed age groups of several Lake Ontario salmonids show that the average PCB and mirex concentrations decreased in the edible portions of the fish between 1986 and 1988 (Johnson, 1989). Mirex concentrations in four-year-old Lake Ontario lake trout fluctuated significantly ($p<0.05$) between 1985 and 1987 (IJC, 1989). Curiously, mirex concentrations increased in lake trout collected near the Credit River in 1987 (M. Whittle, Fisheries and Oceans, Pers. comm.). This increase coincided with substantial mirex residue increases in the nearshore shiner collections from western and eastern Lake Ontario (Appendix II).

BAY OF QUINTE

Collections of young-of-the-year forage fish from the Bay of Quinte consisted largely of yellow perch, therefore contaminant values from this survey are not directly comparable to values in other sections of this report. Data from inter-species comparisons indicate that significant differences exist between organochlorine accumulations in spottail shiners and yellow perch (Suns and Hitchin, in press).

Fish were collected from 3 sites on the Bay of Quinte, 2 sites on Trent River and 1 site on the Moira, Salmon and Napanee Rivers (Appendix IX). All fish collections consisted of YOY yellow perch, except the Napanee River collection, where YOY spottail shiners were taken. Because of the species differences, contaminant values for the Napanee River should not be compared with data from other sites on the Bay. Since the Trent River contributes 50% of the total inflow to the Bay, (Sly, 1986), two collection sites on the Trent River were included in this survey.

Of the 8 sites sampled in 1987/88, total PCB concentrations exceeded the IJC Aquatic Life Guideline of 100 ng/g in 4 of 8 (50%) collections (Appendix VIII). The highest PCB concentrations were found in perch samples downstream of the Domtar Plant on the Trent River. However, the available data base was not large enough to identify sources of PCBs to the river. Further collections from the river should provide more

detail on PCB spatial trends in the Trent. Of particular interest were the high pentachlorophenol concentrations in perch from the last collection (1988) below Domtar. The spatial pattern from the 1987 collection suggests that pentachlorophenol originated from Domtar operations. Concentrations of total DDT, HCB and OCS were found in some of the collections, while mirex, chlordane, BHC, heptachlor, aldrin and toxaphene were not detected.

The Trent River estuary was the only collection site with a sufficiently large data base for temporal trend assessment. Both PCBs and total DDT concentrations declined significantly ($p<0.05$) over time.

ST. LAWRENCE RIVER

Differences between the mean concentrations of total PCBs at 14 St. Lawrence River sites were significant (ANOVA; $F = 265.4$; $p<0.05$). The highest PCB concentration was found in shiner samples collected near the General Motors Plant on the New York shoreline, and the lowest at MacDonnell Island, upstream of the Cornwall Hydro dam (Figure 35; Appendix X). PCB concentrations were generally higher in shiners from the New York shoreline, particularly in collections from the Grass River and at the General Motors Plant on the St. Lawrence(Figure 36). Sediment and water quality surveys have identified areas near the General Motors Plant and Alcoa on the Grass River as PCB-contaminated (Kauss et al., 1988).

Significant differences (ANOVA; $F = 18.8$; $p<0.05$) in total DDT concentrations were found at the 14 St. Lawrence River collection sites. The highest concentration was found in the Cornwall Island North Samples, and the lowest in the Grass River and General Motors Plant collections (Figure 35).

PCB concentrations in shiners exceeded the IJC Aquatic Life Guideline at 8 of 14 (57%) St. Lawrence River sites sampled. None of the other organochlorine residues exceeded the Wildlife Protection Guidelines or Objectives. Although contributions from DDT residues raised the Forage Fish Contaminant Index at 3 Ontario shoreline collections, PCBs remained the main component of the Index (Figure 36).

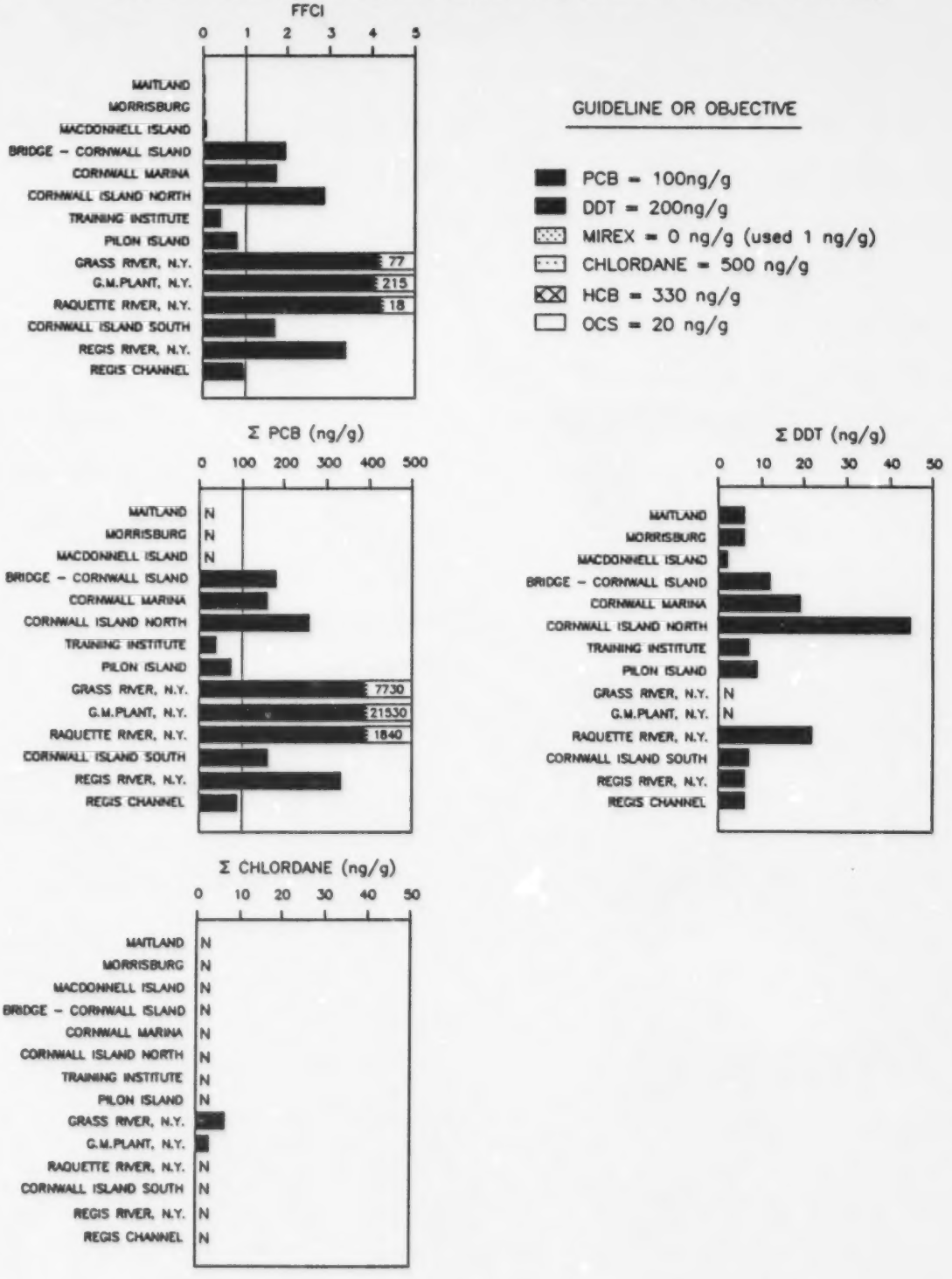
FIGURE 35: SITE-SPECIFIC COMPARISON OF PCB RESIDUES (ng/g) IN YOUNG-OF-THE-YEAR SPOTAIL SHINERS FROM THE ST. LAWRENCE RIVER FOR THE MOST RECENT YEAR, 1986, 1987 OR 1988, USING TUKEY'S MULTIPLE RANGE TEST (95% CONFIDENCE LIMITS) ON LOG TRANSFORMED DATA. (ND = NOT DETECTED).

SITE	MEAN [PCB]	HOMOGENOUS GROUPS
MACDONNELL ISLAND	ND	
MAITLAND	ND	
MORRISBURG	ND	
TRAINING INSTITUTE	38	
PILON ISLAND	74	
REGIS CHANNEL	91	
REGIS RIVER	126	
CORNWALL MARINA	161	
CORNWALL ISLAND SOUTH	164	
BRIDGE CORNWALL ISLAND	182	
CORNWALL ISLAND NORTH	261	
RAQUETTE RIVER	1837	
GRASS RIVER	7729	
G.M.PLANT	21529	

SITE-SPECIFIC COMPARISON OF DDT RESIDUES (ng/g) IN YOUNG-OF-THE-YEAR SPOTTAIL SHINERS FROM THE ST. LAWRENCE RIVER FOR THE MOST RECENT YEAR, 1986, 1987 OR 1988, USING TUKEY'S MULTIPLE RANGE TEST (95% CONFIDENCE LIMITS) ON LOG TRANSFORMED DATA. (ND = NOT DETECTED).

SITE	MEAN [DDT]	HOMOGENOUS GROUPS
G.M.PLANT	ND	
GRASS RIVER	ND	
MACDONNELL ISLAND	2	
MAITLAND	6	
CORNWALL ISLAND SOUTH	7	
REGIS CHANNEL	6	
MORRISBURG	6	
REGIS RIVER	7	
TRAINING INSTITUTE	7	
PILON ISLAND	9	
BRIDGE CORNWALL ISLAND	12	
CORNWALL MARINA	19	
RAQUETTE RIVER	22	
CORNWALL ISLAND NORTH	46	

FIGURE 36: ST.LAWRENCE RIVER FORAGE FISH CONTAMINANT INDEX (FFCI) FOR CONTAMINANTS WITH WILDLIFE PROTECTION GUIDELINES OR OBJECTIVES. VALUES ARE THE SUM OF MEASURED CONCENTRATIONS IN YOY SPOTTAIL SHINERS (MOST RECENT YEAR, 1986, 1987 OR 1988) DIVIDED BY THE GUIDELINE FOR EACH CONTAMINANT. WILDLIFE RISK LEVEL = 1. (N = NOT DETECTED).

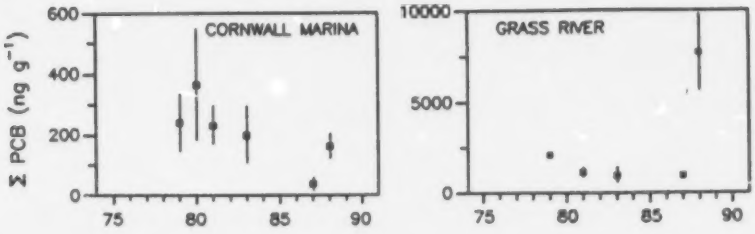


Low concentrations of HCB and chlordane were found in some of the recent St. Lawrence River collections, while mirex OCS, heptachlor, aldrin, BHC and toxaphene were not detected.

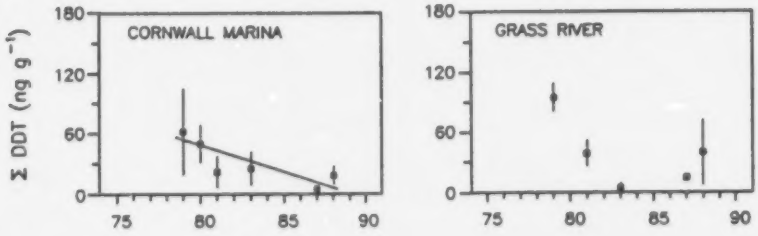
Of the 14 sites sampled, only the Cornwall Marina and Grass River had sufficiently large data bases for temporal trend assessment. PCB residues in shiners from Cornwall Marina and the Grass River did not decrease significantly ($p>0.05$) over time (Figure 37). Total DDT, chlordane and mirex declined in the Cornwall Marina collections ($p<0.05$) over time, while they did not in the Grass River samples.

Total PCB concentrations in shiners from the General Motors Plant, Grass and Raquette River sites increased substantially in 1988. Although these increases indicate elevated PCB availability, reasons for these increases are not known.

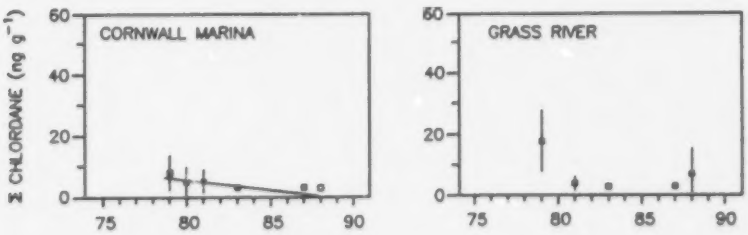
FIGURE 37: TEMPORAL TRENDS OF Σ PCB CONCENTRATIONS IN YOUNG-OF-THE-YEAR SPOTTAIL SHINERS FROM THE ST.LAWRENCE RIVER. VALUES ARE MEANS +/- 95% CONFIDENCE LIMITS. SIGNIFICANT CORRELATIONS WITH TIME (P<0.05) ARE INDICATED WITH A STRAIGHT LINE.



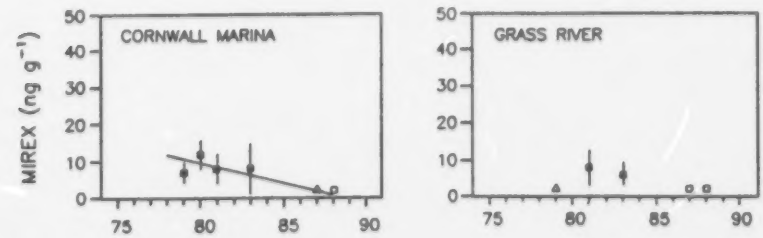
TEMPORAL TRENDS OF Σ DDT CONCENTRATIONS IN YOUNG-OF-THE-YEAR SPOTTAIL SHINERS FROM THE ST.LAWRENCE RIVER. VALUES ARE MEANS +/- 95% CONFIDENCE LIMITS. SIGNIFICANT CORRELATIONS WITH TIME (P<0.05) ARE INDICATED WITH A STRAIGHT LINE.



TEMPORAL TRENDS OF Σ CHLORDANE CONCENTRATIONS IN YOUNG-OF-THE-YEAR SPOTTAIL SHINERS FROM THE ST.LAWRENCE RIVER. VALUES ARE MEANS +/- 95% CONFIDENCE LIMITS. SIGNIFICANT CORRELATIONS WITH TIME (P<0.05) ARE INDICATED WITH A STRAIGHT LINE. (□ - NOT DETECTED).



TEMPORAL TRENDS OF MIREX CONCENTRATIONS IN YOUNG-OF-THE-YEAR SPOTTAIL SHINERS FROM THE ST.LAWRENCE RIVER. VALUES ARE MEANS +/- 95% CONFIDENCE LIMITS. SIGNIFICANT CORRELATIONS WITH TIME (P<0.05) ARE INDICATED WITH A STRAIGHT LINE. (□ - NOT DETECTED, Δ - TRACE).



CONCLUSIONS AND RECOMMENDATIONS

The distribution patterns of PCB residues in Great Lakes shiners showed a considerable spatial variability. It may, therefore, be concluded that watershed inputs, rather than atmospheric, govern PCB bioavailability in the nearshore of the Great Lakes. PCB concentrations in recent shiner collections were substantially lower than PCBs in samples from the 1970's. However, 38% of the recent Great Lakes shiner collections had PCB concentrations in excess of the IJC Aquatic Life Guideline. To meet the requirements of the Great Lakes Water Quality Agreement, further reductions of watershed inputs of PCBs is necessary.

Likewise, mirex concentrations in shiners exceeded the IJC Aquatic Life Guideline in 19% of the recent shiner collections from the Niagara River and Lake Ontario. Mirex inputs from the Niagara RIver to Lake Ontario occur on an intermittent basis.

Of all the compounds analyzed, metabolites of DDT had the widest distributions in the Great Lakes. However, total DDT concentrations in the majority of recent shiner collections were lower than residues in samples from the 1970's. None of the samples analyzed had total DDT concentrations in excess of the Fish Flesh Criterion.

Total chlordane concentrations in most of the recent shiner collections were much lower than chlordane residues in samples from the 1970's. Of the 82 sites sampled, chlordane was detected only at 12 sites, and none of the collections had chlordane

concentrations in excess of the Fish Flesh Guideline.

Shiner collections from the Niagara River at Love Canal, and downstream of the Sarnia industrial complex have identified octachlorostyrene and hexachlorobenzene enrichment. Octachlorostyrene concentrations in the St. Clair River samples exceeded the Fish Flesh Criterion. While the data base for the St. Clair River collections is small, octachlorostyrene and hexachlorobenzene residues appear to be declining.

The Forage Fish Contaminant Index showed that due to the contaminant burdens, Wildlife Risk Level was exceeded in 43% of the Great Lakes shiner collections. The Index offers an alternative to the single compound assessment by evaluating the sum-total of the principal contaminants. However, Index data from this survey provide only a partial assessment of water quality. Further work in criteria development is necessary at the isomer-specific level for PCBs, dibenzo-p-dioxins and dibenzofurans.

Special attention should be given to collection sites where PCB concentrations in shiners tended to increase during the 1980's, such as Centre Creek, Twelve Mile Creek and the Credit River. Similarly, shiner collections from Frenchman's Creek, and Twelve Mile Creek should be monitored for DDT, and collections from the St. Clair River for octachlorostyrene.

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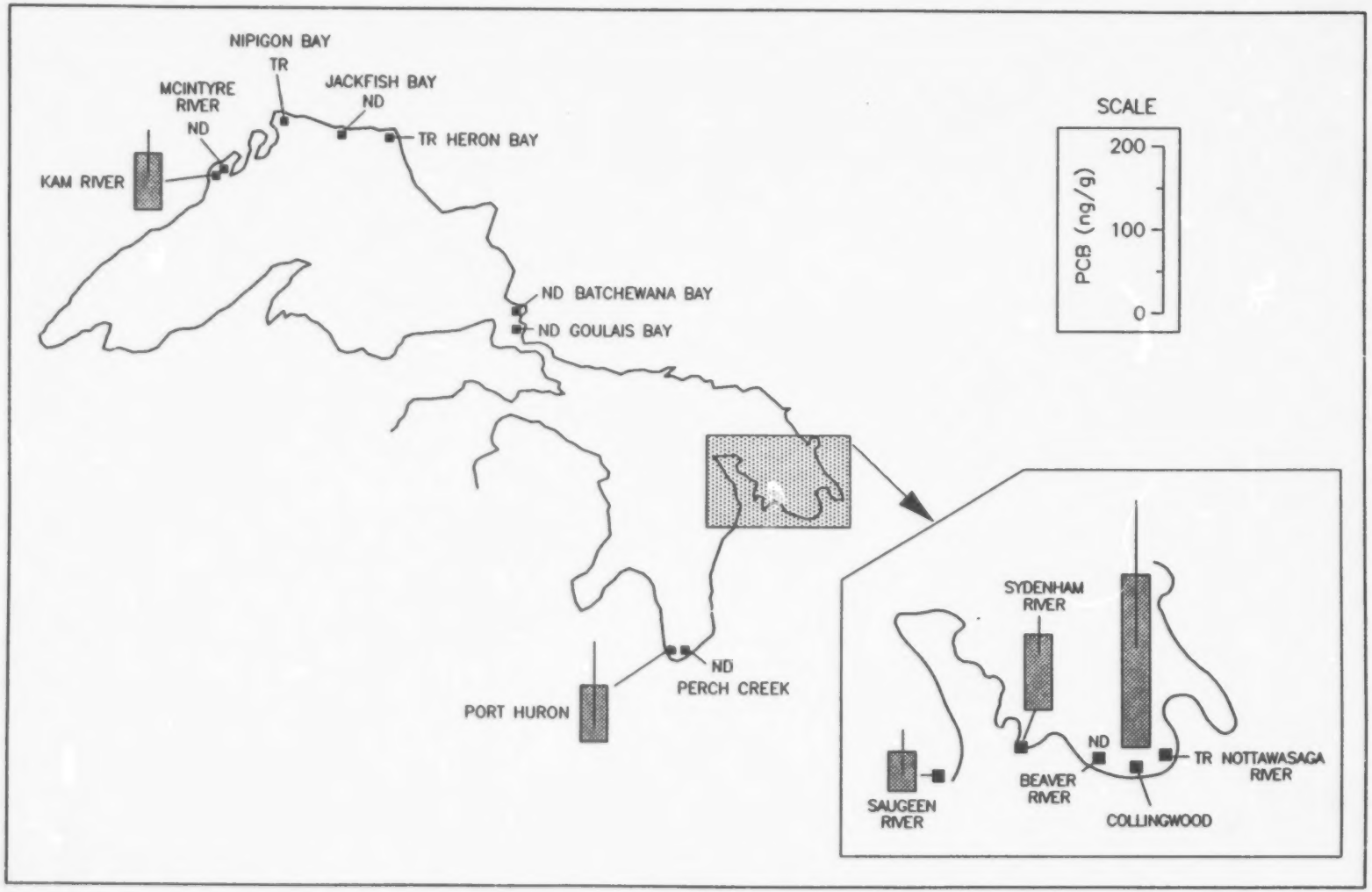
APPENDIX I: SPOTTAIL SHINER COLLECTION SITES AND SPATIAL DISTRIBUTION OF Σ PCB CONCENTRATIONS (ng/g) IN YOUNG-OF-THE-YEAR SPOTTAIL SHINERS FROM LAKE SUPERIOR AND LAKE HURON FOR THE MOST RECENT YEAR, 1986, 1987 OR 1988. VALUES ARE MEANS +/- 95% CONFIDENCE LIMITS. (ND = NOT DETECTED, TR = TRACE).



APPENDIX II: ORGANOCHLORINE CONCENTRATIONS IN YOUNG-OF-THE-YEAR SPOTTAIL SHINERS FROM THE GREAT LAKES AND CONNECTING CHANNELS (1975-1988). VALUES ARE MEANS +/- STANDARD DEVIATION.

SAMPLING SITE	YEAR	n	TOTAL LENGTH (mm)	FAT (%)	PCB (ng/g)	DDT (ng/g)	MIREX (ng/g)	CHLOR DANE (ng/g)	BHC (ng/g)	HCB (ng/g)	OCS (ng/g)
LAKE SUPERIOR											
PINE BAY	1983	7	38-3	2.6-1.0	ND	TR	ND	ND	ND	ND	ND
KAM RIVER	1979	8	30-4	2.0-0.6	24- 14	10-6	ND	4-2	ND	ND	-
	1983	7	37-3	3.2-0.7	82- 13	10-3	ND	ND	3-1	ND	ND
	1984	7	37-3	1.4-0.3	64- 10	4-1	ND	ND	ND	ND	ND
	1986	4	30-3	1.0-0.3	ND	ND	ND	ND	ND	ND	ND
	1988	7	35-1	1.2-0.2	67-27	2-2	ND	ND	ND	TR	ND
MISSION RIVER	1980	7	46-3	2.0-0.2	77- 15	25-7	ND	34-9	1-0	ND	-
	1983	7	44-3	3.8-0.6	139- 21	5-3	ND	ND	TR	TR	ND
	1984	7	41-4	2.1-0.5	50- 11	5-3	ND	TR	TR	ND	ND
MCINTYRE RIVER	1986	4	31-4	2.2-0.5	ND	ND	ND	ND	ND	ND	ND
BLACK BAY	1983	7	42-3	2.1-0.4	ND	3-0	ND	ND	TR	ND	ND
NIPIGON BAY	1979	8	32-4	3.5-0.4	25- 14	21-13	ND	7-4	ND	ND	-
	1983	7	35-3	2.6-0.7	51- 5	2-1	ND	ND	3-2	ND	ND
	1984	7	27-3	0.7-0.1	TR	TR	ND	ND	ND	ND	ND
	1986	3	27-4	2.2-0.7	TR	ND	ND	ND	ND	TR	ND
TERRACE BAY	1983	7	31-5	4.1-1.0	38- 8	2-1	ND	ND	2-2	ND	ND
JACKFISH BAY	1979	7	33-4	2.0-0.4	TR	ND	ND	ND	ND	ND	-
	1983	7	36-2	4.1-0.5	89- 22	3-1	ND	ND	5-1	TR	ND
	1984	7	31-4	0.7-0.1	TR	2-1	ND	ND	ND	ND	ND
	1986	3	35-4	2.2-0.2	ND	2-0	ND	ND	ND	4-0	ND
	1987	3	45-2	4.2-0.4	ND	TR	ND	ND	ND	ND	ND
HERON BAY	1979	8	35-2	2.5-0.7	22- 18	TR	ND	TR	ND	ND	-
	1986	5	36-4	2.6-0.3	TR	TR	ND	ND	ND	ND	ND
PIC RIVER	1983	6	45-1	3.2-0.4	ND	2-1	ND	ND	ND	ND	ND
BATCHEWANA BAY	1979	6	35-4	5.2-0.4	ND	ND	ND	ND	ND	ND	-
	1983	7	43-6	2.6-0.2	ND	6-2	ND	TR	ND	ND	ND
	1987	3	44-3	3.4-0.4	ND	2-1	ND	ND	1-1	2-1	ND
GOULAIS BAY	1986	4	40-5	2.2-0.1	TR	3-2	ND	ND	ND	ND	ND
	1987	3	49-3	2.6-0.4	ND	5-1	ND	ND	ND	ND	ND
ST.MARY'S RIVER											
LITTLE LAKE GEORGE	1979	6	32-6	2.5-0.9	TR	5-4	ND	3-1	5-3	ND	-
	1987	5	62-4	2.4-0.5	ND	ND	ND	ND	ND	ND	ND

APPENDIX II: (cont.- page 2)

SAMPLING SITE	YEAR	n	TOTAL LENGTH (mm)	FAT (%)	PCB (ng/g)	DDT (ng/g)	MIREX (ng/g)	CHLOR DANE (ng/g)	BHC (ng/g)	HCB (ng/g)	OCS (ng/g)
LAKE HURON - SEVERN SOUND											
BEAUSOLEIL ISLAND	1987	7	58-1	4.3-0.4	ND	7-2	ND	ND	ND	ND	ND
MICHAUD POINT	1987	7	54-1	4.2-0.3	ND	6-3	ND	ND	ND	ND	ND
ASYLUM POINT	1987	7	58-2	4.3-0.4	ND	11-8	ND	ND	ND	2-1	ND
TANNERY POINT	1987	7	63-2	5.9-0.8	27-13	6-2	ND	ND	ND	ND	ND
PENETANG WPCP	1987	7	52-2	3.7-0.4	ND	5-3	ND	ND	ND	ND	ND
MIDLAND DOWNTOWN	1987	7	60-1	4.8-1.1	164-42	9-1	ND	ND	ND	ND	ND
MIDLAND WPCP	1987	5	68-6	6.4-0.8	52-23	16-18	ND	ND	1-1	ND	ND
WYE RIVER	1987	7	62-2	6.1-0.8	ND	9-1	ND	ND	ND	ND	ND
GRANDVIEW BEACH	1987	7	63-2	6.6-0.4	24-18	13-5	ND	ND	ND	TR	ND
PORT MCNICOLL WPCP	1987	6	55-2	3.8-0.7	ND	7-2	ND	ND	ND	1-1	ND
HOG BAY	1987	7	52-1	3.8-0.6	59-30	7-3	ND	ND	ND	ND	ND
METHODIST ISLAND	1987	7	52-2	3.1-0.4	ND	4-2	ND	ND	ND	3-2	ND
VICTORIA HARB. WPCP	1987	4	52-4	3.1-0.3	ND	5-0	ND	ND	ND	TR	ND
TANNER POINT	1987	6	72-7	5.8-0.8	ND	12-4	ND	ND	ND	TR	ND
WAUBAUSHENE	1987	7	65-2	6.6-0.3	ND	10-3	ND	ND	ND	1-1	ND

APPENDIX II: (cont.- page 3)

SAMPLING SITE	YEAR	n	TOTAL LENGTH (mm)	FAT (%)	PCB (ng/g)	DDT (ng/g)	MIREX (ng/g)	CHLOR DANE (ng/g)	BHC (ng/g)	HCB (ng/g)	OCS (ng/g)
LAKE HURON											
BLIND RIVER	1979	8	35-5	1.5-1.0	ND	1-2	ND	3-2	ND	ND	-
	1981	5	48-5	1.8-0.7	53- 10	33-7	ND	16-4	6-1	ND	-
FRENCH RIVER	1979	8	34-3	2.0-0.8	ND	ND	ND	ND	ND	ND	-
SEGUIN RIVER	1979	7	43-4	1.1-0.2	ND	ND	ND	ND	ND	ND	-
THUNDER BEACH	1980	7	47-2	3-7-0.8	35- 32	25-15	ND	13-4	5.2	ND	-
NOTTAWASAGA RIVER	1977	10	58-1	8.0-0.2	90- 12	120-33	ND	17-2	9-5	ND	-
	1982	3	52-2	5.2-0.1	43- 30	36-24	ND	3-1	4-2	ND	ND
	1986	2	59-7	6.2-0.8	44- 16	34-3	ND	TR	ND	ND	ND
	1987	7	50-4	3.0-0.7	TR	13-9	ND	ND	ND	5-3	ND
PRETTY RIVER	1979	8	38-3	1.2-0.5	59- 9	17-14	ND	ND	ND	ND	-
COLLINGWOOD	1987	7	53-4	2.9-0.3	206- 88	43-25	ND	ND	ND	ND	ND
BEAVER RIVER	1979	8	41-5	1.2-0.5	36- 5	9-5	ND	ND	ND	ND	-
	1987	6	36-4	2.0-0.2	ND	13-7	ND	ND	ND	2-1	ND
SYDENHAM RIVER	1986	7	44-3	2.8-0.2	89- 23	15-5	ND	ND	ND	ND	ND
SAUGEEN RIVER	1980	7	45-5	2.8-0.3	69- 9	19-4	ND	5-3	TR	ND	-
	1987	7	50-5	2.2-0.5	47- 26	24-8	ND	ND	ND	2-1	ND
MAITLAND RIVER	1980	6	46-5	2.2-1.0	47- 28	13-6	ND	4-4	1-1	1-0	-
AUSABLE RIVER	1979	4	55-6	2.8-0.4	121- 37	59-21	ND	10-6	8-2	TR	-
	1980	7	52-4	4.4-0.4	34- 4	12-2	ND	10-6	8-2	ND	-
PERCH CREEK	1978	8	54-2	2.6-0.3	304- 20	71-59	ND	29-20	12-4	ND	-
	1980	7	50-5	3.5-1.0	32- 18	8-5	ND	17-6	7-3	ND	-
	1988	6	33-1	1.2-0.3	ND	2-2	ND	ND	ND	ND	ND
PORT HURON	1986	5	50-3	6.0-0.7	67- 38	18-12	ND	ND	TR	3-1	4-2
ST.CLAIR RIVER											
SUNCOR	1983	4	46-7	2.8-0.3	146- 29	16-4	ND	3-1	ND	231-26	560-148
LAMBTON GEN.STAT.	1985	4	62-4	3.4-0.4	422-152	6-5	ND	ND	ND	60-13	81-22
	1986	5	55-4	2.8-0.6	283- 66	10-5	ND	ND	ND	31-13	104-46
	1987	7	66-4	5.0-0.7	81- 12	17-10	ND	2-1	3-1	13-2	35-3
	1988	6	61-2	3.7-0.4	148-23	3-4	ND	ND	ND	8-1	23-5
SOUTH CHANNEL	1982	7	59-7	2.0-0.3	71- 25	4-3	ND	11-8	2-1	13-7	95-10
	1986	6	52-6	2.0-0.3	79- 31	8-4	ND	ND	ND	12-2	49-9

APPENDIX II: (cont.- page 4)

SAMPLING SITE	YEAR	n	TOTAL LENGTH (mm)	FAT (%)	PCB (ng/g)	DDT (ng/g)	MIREX (ng/g)	CHLOR DANE (ng/g)	BHC (ng/g)	HCB (ng/g)	OCS (ng/g)
LAKE ST.CLAIR											
CHENAL ECARTE	1983	7	57-4	1.5-0.1	62- 9	10-1	ND	ND	TR	10-3	28-8
	1987	7	53-4	1.6-0.2	ND	5-2	ND	4-2	ND	6-1	18-6
MITCHELL BAY	1978	8	54-3	1.8-0.2	94- 50	24-15	ND	7-3	2-1	ND	-
	1979	7	55-5	1.0-0.2	ND	11-3	ND	3-1	2-1	ND	-
	1982	7	58-5	2.2-0.2	33- 14	4-4	ND	TR	TR	1-0	2-0
	1984	7	58-6	2.4-0.4	38- 32	4-3	ND	TR	ND	ND	ND
	1985	6	61-5	3.4-0.8	105- 45	7-7	ND	ND	ND	10-3	13-4
	1986	7	57-5	1.4-0.1	TR	4-1	ND	ND	ND	2-2	2-1
	1987	7	58-4	1.8-0.1	40- 26	7-2	ND	ND	ND	2-1	5-4
THAMES RIVER	1977	8	59-1	1.5-0.3	67- 18	17-4	ND	5-3	ND	ND	-
	1979	4	70-5	2.4-0.1	23- 10	8-3	ND	12-4	6-0	ND	-
	1982	7	62-5	1.8-0.2	26- 7	2-2	ND	TR	1-1	ND	11-13
	1986	7	59-4	2.0-0.2	ND	6-5	ND	ND	ND	TR	2-1
PIKE CREEK	1978	8	57-2	2.0-0.2	269- 55	17-4	ND	10-9	ND	ND	-
	1979	4	63-6	2.1-0.5	114- 61	46-19	ND	10-4	TR	5-4	-
	1980	7	62-6	1.2-0.2	67- 21	18-3	ND	7-1	2-1	3-1	-
	1982	7	61-6	1.7-0.2	64- 10	11-4	ND	TR	TR	1-1	5-2
	1983	7	52-4	2.0-0.0	29- 5	2-3	ND	TR	TR	ND	3-1
	1984	6	60-5	1.6-0.2	95- 50	8-10	ND	3-1	ND	ND	3-2
	1987	7	71-6	2.9-0.4	40- 16	14-4	ND	ND	ND	3-0	5-1
DETROIT RIVER											
WINDSOR STP	1987	5	61-5	3.6-0.3	198- 50	4-3	ND	ND	ND	5-1	6-1
TURKEY CREEK	1983	4	59-5	3.5-1.0	316-172	12-3	ND	3-1	4-1	4-4	10-2
	1984	7	60-6	2.2-0.4	364- 71	10-7	TR	ND	ND	7-2	9-4
	1986	7	61-5	2.6-0.3	206- 75	16-6	ND	TR	ND	8-3	11-3
	1987	7	58-5	2.3-0.3	84- 26	21-15	ND	ND	ND	3-1	4-1
GRASSY ISLAND	1983	5	63-4	2.4-0.9	912-195	16-6	ND	4-2	5-2	4-1	2-1
	1984	2	61-5	3.8-0.6	510- 28	15-10	ND	7-6	ND	2-1	6-1
FIGHTING ISLAND	1980	6	55-4	2.2-0.5	96- 24	6-1	ND	8-2	4-2	11-3	-
	1983	6	59-3	2.7-1.0	290- 59	ND	ND	4-1	6-5	4-1	9-1
	1984	7	55-6	2.2-0.3	203- 37	10-8	ND	TR	ND	6-1	9-2
	1986	2	52-1	1.8-0.1	184-69	7-4	ND	ND	ND	ND	4-1

APPENDIX II: (cont.- page 5)

SAMPLING SITE	YEAR	n	TOTAL LENGTH (mm)	FAT (%)	PCB (ng/g)	DDT (ng/g)	MIREX (ng/g)	CHLOR DANE (ng/g)	BHC (ng/g)	HCB (ng/g)	OCS (ng/g)
DETROIT RIVER											
AMHERSTBURG	1982	5	66-3	2.9-0.2	304-116	2-1	ND	9-3	2-1	7-1	10-2
	1983	7	64-6	2.3-0.7	153- 65	17-12	ND	6-2	4-1	5-2	8-2
	1984	7	67-10	3.4-0.3	330- 86	7-3	ND	TR	TR	6-2	9-2
	1985	6	67-4	4.0-0.7	481- 69	TR	ND	ND	ND	11-2	8-1
	1986	7	61-5	1.9-0.2	214- 67	11-2	ND	TR	ND	7-1	11-1
	1987	7	60-5	2.5-0.6	124- 31	10-4	ND	ND	ND	3-1	5-1
CELERON ISLAND	1982	5	63-3	3.8-0.2	1696-438	5-11	ND	8-5	2-1	8-1	6-1
	1983	6	72-3	2.7-1.0	1709-415	16-7	ND	12-7	3-1	2-2	4-1
STURGEON BAR	1982	5	64-4	2.0-0.2	2997-570	ND	ND	10-8	ND	5-3	6-1
	1984	7	71-10	4.1-0.7	1448-260	36-11	ND	11-4	TR	9-3	9-2
	1985	3	73-7	3.7-0.9	2610-209	39-14	ND	ND	ND	9-1	10-1
	1986	7	61-8	3.2-0.5	1156-189	52-15	ND	9-3	ND	9-2	5-1
LAKE ERIE											
BIG CREEK	1977	9	57-3	0.9-0.1	447- 40	75-15	ND	ND	ND	ND	-
	1978	6	55-2	1.0-0.2	510- 93	42-22	ND	8-5	TR	ND	-
	1980	7	66-4	1.1-0.1	387- 95	27-11	ND	6-3	TR	ND	ND
	1981	7	60-5	2.1-0.3	307- 85	31-15	ND	7-3	5-1	3-2	ND
	1982	7	57-5	1.7-0.3	189- 69	2-1	ND	ND	ND	3-1	5-1
	1984	5	65-7	1.9-0.2	480- 73	2-2	ND	ND	ND	2-1	6-2
	1985	4	61-7	2.0-0.3	205-117	2-1	ND	ND	ND	3-3	4-2
	1986	7	61-7	1.7-0.3	201- 70	17-7	ND	ND	ND	2-1	4-2
	1987	6	57-7	1.5-0.2	95- 17	10-4	ND	ND	ND	2-0	2-0
LEAMINGTON	1975	5	57-3	1.8-0.2	844-403	95-22	ND	ND	ND	ND	-
	1977	10	58-4	1.6-0.3	477-113	141-47	ND	27-8	ND	ND	-
	1978	8	55-1	1.7-0.3	528- 55	47-10	ND	18-5	TR	ND	-
	1979	7	61-4	3.4-0.5	337- 79	18-4	ND	14-5	4-1	2-1	-
	1980	7	60-4	1.4-0.1	150- 37	21-4	ND	8-2	1-1	ND	-
	1981	7	59-5	1.7-0.3	266- 38	51-34	ND	8-1	4-1	TR	-
	1982	7	60-5	1.6-0.1	236- 30	44-15	ND	9-4	5-2	2-3	3-1
	1983	7	62-5	2.0-0.0	260-112	13-4	ND	3-1	3-0	1-0	ND
	1984	7	59-7	2.0-0.3	359-112	21-6	ND	TR	ND	1-0	4-1
	1985	5	66-4	3.2-0.6	459-309	34-25	ND	ND	ND	4-4	3-2
	1986	7	54-4	1.1-0.1	220- 80	-	ND	9-4	ND	ND	1-1
	1987	7	66-4	3.0-0.4	185- 38	22-17	ND	3-1	ND	2-1	2-2
	1988	7	52-2	1.6-0.1	116-21	13-8	ND	ND	ND	ND	ND
WHEATLEY	1988	4	48-2	2.5-0.2	385-143	36-8	ND	ND	ND	ND	3-4
PORT STANLEY	1978	8	51-1	2.2-0.9	195-130	17-4	ND	15-6	ND	TR	-
	1979	8	44-7	1.4-0.7	53- 31	13-3	ND	6-2	ND	ND	-
	1983	4	60-8	2.5-0.3	232- 30	23-15	ND	TR	1-1	ND	ND

APPENDIX II: (cont.- page 6)

SAMPLING SITE	YEAR	n	TOTAL LENGTH (mm)	FAT (%)	PCB (ng/g)	DDT (ng/g)	MIREX (ng/g)	CHLORDANE (ng/g)	BHC (ng/g)	HCB (ng/g)	OCS (ng/g)
LAKE ERIE											
PORT ROWAN	1975	5	59-4	2.1-0.6	59- 29	133-66	ND	ND	ND	ND	-
	1979	8	71-5	1.9-0.4	30- 9	54-19	ND	23-3	TR	ND	ND
PORT DOVER	1988	5	45-3	2.2-0.4	143-60	51-34	ND	2-2	ND	TR	TR
CENTRE CREEK	1979	5	56-4	3.1-0.1	47- 22	24-5	ND	5-2	4-1	ND	ND
	1982	7	54-5	2.4-0.2	54- 30	6-6	ND	10-4	TR	ND	2-3
	1983	7	61-5	2.2-0.3	49- 9	22-10	ND	TR	TR	ND	ND
	1984	5	58-6	3.1-0.3	43- 11	16-4	ND	ND	ND	ND	ND
	1987	4	62-6	3.0-0.5	70- 32	7-2	ND	ND	ND	ND	ND
NANTICOKE CREEK	1979	5	57-5	1.8-0.1	50- 8	31-8	ND	7-3	ND	ND	-
	1981	3	56-4	2.8-0.6	36- 32	16-6	ND	3-2	3-1	ND	-
	1982	6	52-8	2.6-0.5	30- 8	9-6	ND	4-2	2-1	ND	ND
GRAND RIVER	1976	8	46-2	2.6-0.3	146- 12	42-11	ND	10-4	6-3	ND	-
	1977	9	45-3	1.5-0.2	56- 12	16-2	ND	ND	ND	ND	-
	1979	8	56-7	2.0-0.5	90- 40	24-5	ND	4-2	7-5	ND	-
	1982	6	53-4	1.8-0.4	48- 6	5-4	ND	TR	1-1	ND	ND
	1986	4	43-4	4.6-0.3	26- 5	7-1	ND	ND	ND	ND	ND
PORT COLBORNE	1975	5	55-3	1.2-0.3	82- 29	32-23	ND	ND	ND	ND	-
THUNDER BAY BEACH	1978	8	52-2	3.0-0.7	157- 28	38-12	ND	7-3	5-1	ND	-
	1979	5	54-7	1.9-0.3	31- 12	14-5	ND	9-2	ND	ND	-
	1980	7	54-7	1.9-0.7	95- 29	29-12	3-1	20-9	3-1	ND	ND
	1982	7	53-6	1.3-0.4	60- 17	19-8	ND	ND	ND	TR	ND
	1983	7	59-4	1.9-0.5	31- 6	TR	ND	3-1	TR	ND	ND
	1984	7	54-5	1.7-0.2	41- 7	7-1	ND	ND	ND	ND	ND
	1986	6	43-6	1.6-0.6	ND	5-5	ND	ND	ND	ND	ND
	1987	7	58-5	1.4-0.2	ND	5-2	ND	ND	ND	ND	ND
NIAGARA RIVER											
FORT ERIE	1982	6	53-2	2.6-0.3	181- 69	31-12	ND	6-4	4-1	TR	ND
	1983	7	60-5	2.4-0.3	66- 20	7-6	ND	ND	TR	ND	ND
	1984	7	48-5	2.1-0.3	118- 12	25-8	ND	TR	TR	ND	ND
	1985	7	56-4	3.4-0.7	63- 10	10-6	ND	ND	ND	TR	ND
	1987	7	57-3	2.8-0.4	34- 27	19-2	ND	ND	ND	ND	ND
STRAWBERRY ISLAND	1983	6	66-3	3.5-0.3	60- 28	23-5	ND	4-1	4-2	ND	ND
	1984	7	57-4	1.9-0.3	69- 22	9-2	ND	ND	ND	ND	ND
FRENCHMANS CREEK	1980	5	53-2	1.7-0.4	66- 31	13-9	ND	9-3	3-1	ND	-
	1981	5	49-3	1.6-0.2	164- 56	37-19	ND	TR	1-1	ND	-
	1982	7	56-3	3.7-0.5	216- 34	57-10	ND	8-6	6-1	1-1	ND
	1983	7	56-5	2.2-0.2	64- 21	24-6	ND	TR	ND	ND	ND
	1985	7	58-3	4.1-0.4	81- 16	73-49	ND	2-1	ND	2-1	ND

APPENDIX II: (cont.- page 7)

SAMPLING SITE	YEAR	n	TOTAL LENGTH (mm)	FAT (%)	PCB (ng/g)	DDT (ng/g)	MIREX (ng/g)	CHLOR DANE (ng/g)	BHC (ng/g)	HCB (ng/g)	OCS (ng/g)
NIAGARA RIVER											
PETITE FLUME	1984	7	60-3	3.0-0.3	896-234	14-3	ND	4-1	ND	780-84	28-13
	1985	5	69-4	5.4-0.6	251- 71	15-2	ND	8-8	ND	5-4	2-1
WHEATFIELD	1983	6	62-3	2.9-0.9	276-160	28-8	ND	6-2	5-1	3-2	ND
	1984	7	59-4	2.4-0.2	608-140	TR	ND	3-1	ND	11-4	TR
	1985	7	64-4	3.5-0.6	261- 45	12-2	ND	ND	ND	7-2	1-1
	1986	7	55-4	3.0-0.5	282-110	13-3	ND	ND	ND	6-1	8-3
	1987	5	61-4	1.7-0.4	86- 22	6-1	ND	ND	ND	3-1	2-2
102nd STREET	1980	7	54-4	2.2-0.5	402-109	18-11	5-4	10-3	33-17	ND	-
	1981	7	49-3	1.4-0.2	327- 53	9-4	17-6	11-3	31-11	15-6	-
	1982	6	51-3	1.5-0.2	512-143	18-6	ND	15-6	28-11	8-3	ND
	1984	6	56-4	1.9-0.5	331- 72	6-5	7-6	TR	22-16	36-11	ND
	1986	6	52-3	2.0-0.3	264- 80	2-2	5-3	ND	3-2	34-19	ND
	1987	5	61-3	2.2-0.4	172- 35	7-6	ND	2-1	6-4	25-10	7-2
CAYUGA CREEK	1981	4	51-4	2.3-0.3	573- 84	23-4	18-4	18-4	34-9	11-2	-
	1982	6	52-2	2.7-0.8	880-136	50-4	6-2	19-7	29-10	12-2	ND
	1983	5	55-5	3.0-0.2	406-194	29-15	9-15	5-4	14-19	5-5	ND
	1985	5	61-4	3.0-0.4	750-180	23-9	ND	3-1	38-17	24-7	ND
SEARCH & RESCUE	1982	5	52-3	3.0-0.5	1091-351	14-7	5-3	13-6	7-3	8-4	6-4
	1983	6	59-5	3.0-0.5	867-153	TR	ND	5-1	TR	TR	3-1
GILL CREEK	1985	5	63-4	3.4-0.5	21960-7117	185-37	ND	3-2	267-71	273-85	ND
USHERS CREEK	1982	7	56-3	3.8-0.5	124- 14	30-5	ND	10-2	ND	1-1	ND
	1983	7	60-5	2.8-0.4	67- 17	24-4	ND	TR	ND	ND	ND
	1984	7	54-5	1.9-0.3	99- 28	23-5	ND	ND	ND	ND	ND
	1985	7	59-4	2.4-0.5	49- 19	15-9	ND	ND	ND	TR	ND
	1986	7	42-5	1.6-0.6	29- 25	12-9	ND	ND	ND	3-2	ND
	1987	7	55-4	2.2-0.6	ND	16-13	ND	ND	ND	ND	ND
WELLAND RIVER E.	1980	5	50-4	2.3-0.6	56- 14	4-3	ND	5-2	1-1	ND	-
	1982	5	52-2	2.2-0.4	96- 5	36-12	ND	7-3	TR	1-1	TR
	1983	5	62-3	4.0-0.7	49- 22	18-6	ND	TR	4-1	ND	ND
	1984	6	54-4	1.6-0.2	67- 16	11-1	ND	ND	ND	ND	ND
WELLAND RIVER W.	1982	5	51-3	2.3-0.3	187- 45	19-15	ND	10-5	TR	1-1	ND
QUEENSTON	1979	7	49-3	2.2-0.4	108- 28	34-9	ND	21-6	4-4	6-3	-
	1980	7	53-2	3.3-0.3	134- 20	11-6	TR	21-19	7-2	1-1	-
	1981	6	49-2	1.2-0.4	329-120	107-57	15-8	47-20	4-3	3-2	-
	1982	5	50-2	1.8-0.4	245- 21	61-19	7-6	8-2	3-1	3-0	2-1
LEWISTON	1981	5	50-3	1.4-0.2	405- 87	74-17	12-3	9-3	ND	3-1	-
	1982	5	50-3	2.1-0.3	180- 63	26-10	6-4	8-2	ND	3-1	1-1
	1986	5	51-3	2.5-0.5	256- 74	27-13	10-2	ND	ND	3-1	1-1
	1988	7	58-1	1.7-0.4	99-36	14-11	ND	ND	ND	TR	TR

APPENDIX II: (cont.- page 8)

SAMPLING SITE	YEAR	n	TOTAL LENGTH (mm)	FAT (%)	PCB (ng/g)	DDT (ng/g)	MIREX (ng/g)	CHLOR DANE (ng/g)	BHC (ng/g)	HCB (ng/g)	OCS (ng/g)
NIAGARA RIVER											
PEGGYS EDDY	1980	7	58-4	2.8-0.5	233-58	36-17	9-6	14-6	15-7	9-7	-
	1981	7	53-4	2.0-0.4	309-90	189-62	6-3	10-14	TR	3-2	-
	1982	6	51-3	2.5-0.5	260-56	47-22	6-2	7-3	3-1	3-1	2-1
	1985	7	59-3	3.2-0.6	85-24	12-6	ND	3-1	ND	1-1	ND
	1987	6	58-4	2.2-0.2	133-92	23-3	ND	ND	ND	4-1	ND
NIAGARA-ON-THE-LAKE	1975	5	56-4	2.3-0.3	690-195	244-52	ND	ND	ND	ND	-
	1977	9	51-3	2.5-0.6	626-154	157-38	13-4	55-26	26-26	27-11	-
	1978	8	51-1	1.9-0.2	320-49	99-49	29-8	8-10	7-2	2-1	-
	1979	8	50-2	2.4-0.4	153-23	26-9	TR	22-18	ND	4-1	-
	1980	7	56-2	2.1-0.4	266-51	41-9	11-2	24-6	26-7	4-3	-
	1981	7	55-3	1.9-0.1	327-62	73-15	10-3	11-4	ND	2-1	-
	1982	5	53-3	2.2-0.4	255-24	82-14	6-2	17-7	4-1	4-1	4-1
	1983	6	59-5	2.5-0.5	136-55	9-9	ND	3-1	ND	3-3	2-1
	1984	7	58-4	2.2-0.2	273-107	71-23	10-6	3-1	ND	15-3	4-1
	1985	7	55-7	2.8-0.3	127-38	13-13	ND	TR	ND	1-1	1-1
	1987	7	60-4	2.6-0.3	116-18	34-9	8-3	TR	ND	3-1	ND
	1988	7	63-1	2.4-0.4	145-59	47-30	ND	ND	ND	TR	TR
LAKE ONTARIO											
WELLAND CANAL	1982	7	48-6	2.0-0.4	158-42	-	6-3	-	-	ND	3-1
	1983	7	63-3	2.7-0.2	229-54	38-13	TR	44-12	ND	3-1	3-1
	1984	6	48-7	2.2-0.2	157-27	12-7	5-3	5-3	ND	ND	ND
	1985	7	57-4	3.4-0.3	255-36	59-13	ND	5-2	ND	9-5	TR
	1986	4	46-5	2.1-0.3	187-41	46-7	ND	TR	ND	2-1	6-2
	1987	7	53-5	1.8-0.2	127-17	39-9	14-2	ND	ND	ND	ND
TWELVE MILE CREEK	1975	5	58-5	5.2-0.9	890-319	98-46	ND	ND	ND	ND	-
	1978	8	51-3	2.9-0.4	349-63	88-17	20-12	26-10	7-2	2-1	-
	1979	8	51-4	2.1-0.4	271-49	66-19	ND	ND	3-1	ND	-
	1980	7	48-6	1.9-0.3	148-28	50-10	TR	7-2	3-1	TR	-
	1981	6	54-5	2.5-0.5	205-15	93-32	TR	6-2	4-1	ND	-
	1982	7	41-5	1.6-0.3	279-26	33-22	21-5	8-4	TR	1-1	5-1
	1983	7	64-3	3.2-0.4	236-47	48-6	8-4	4-2	ND	5-2	5-2
	1984	6	54-4	2.0-0.3	267-45	100-31	7-5	3-1	ND	TR	3-2
	1985	4	56-10	2.5-0.7	337-100	65-19	TR	3-3	ND	3-1	ND
	1986	4	57-7	2.2-0.2	321-97	138-43	ND	3-2	ND	2-1	4-2
	1987	7	60-3	2.2-0.2	207-36	85-13	12-2	ND	2-1	2-1	1-1
BURLINGTON BEACH	1977	9	55-4	5.3-0.7	633-106	267-36	9-2	47-16	11-4	4-2	-
	1980	7	47-6	2.7-0.2	230-54	46-11	TR	14-4	4-1	TR	-
	1983	7	57-4	4.5-0.7	375-68	40-12	7-2	4-2	TR	2-1	TR
	1984	6	33-4	1.6-0.2	113-36	14-6	ND	2-1	ND	-	-
	1985	7	41-3	1.8-0.5	502-128	29-22	ND	TR	ND	7-5	1-1
	1986	5	31-4	2.0-0.5	136-98	19-18	TR	TR	ND	TR	TR
	1987	5	47-2	2.6-0.2	194-20	47-6	7-3	2-1	ND	ND	ND

APPENDIX II: (cont.- page 9)

SAMPLING SITE	YEAR	n	TOTAL LENGTH (mm)	FAT (%)	PCB (ng/g)	DDT (ng/g)	MIREX (ng/g)	CHLOR DANE (ng/g)	BHC (ng/g)	HCB (ng/g)	OCS (ng/g)
LAKE ONTARIO											
BRONTE CREEK	1979	8	53-3	3.5-0.5	188- 48	35-6	ND	19-3	3-2	ND	-
	1985	7	57-4	2.6-0.1	317- 67	65-10	ND	4-1	ND	2-1	2-1
	1987	7	63-3	3.0-0.3	171- 27	36-13	12-3	2-1	ND	ND	ND
OAKVILLE CREEK	1987	7	62-2	2.4-0.2	101- 19	28-6	ND	TR	ND	ND	ND
CREDIT RIVER	1976	10	62-3	2.8-0.5	1315-578	278-106	32-13	50-22	20-9	10-4	-
	1978	8	60-3	2.6-0.3	590- 53	96-12	28-3	37-8	TR	1-1	-
	1979	8	56-3	3.6-0.6	186- 28	70-12	ND	36-6	8-3	ND	-
	1980	7	62-4	2.7-0.6	238- 59	59-20	TR	24-5	5-3	TR	-
	1982	7	52-7	3.2-0.2	183- 27	66-32	7-2	21-7	3-0	2-1	1-1
	1983	7	60-8	3.7-1.5	329- 46	23-11	5-2	5-2	ND	2-0	1-1
	1987	7	65-3	3.7-0.6	258- 10	91-7	37-11	TR	ND	2-1	2-0
	1988	7	66-1	4.0-0.6	264-48	80-55	ND	TR	ND	4-3	1-1
MIMICO CREEK	1981	5	68-4	6.4-0.2	1051-105	135-19	ND	47-3	19-2	ND	-
	1982	6	66-7	5.0-0.3	572- 45	52-7	TR	14-3	5-2	4-1	-
	1983	7	70-4	5.4-0.4	542- 80	41-4	ND	25-3	6-2	13-1	-
	1984	6	69-4	4.5-1.1	378- 69	50-16	ND	18-2	TR	TR	ND
	1987	7	67-6	4.9-0.5	173- 30	35-7	ND	19-5	TR	TR	2-1
HUMBER RIVER	1977	8	62-3	7.3-0.4	2218-263	268-32	5-2	58-16	41-8	5-1	-
	1978	8	58-5	5.8-0.5	2938-391	406-99	15-4	ND	3-4	3-1	-
	1979	8	60-6	4.1-1.3	1223-347	76-12	ND	47-9	4-1	3-1	-
	1980	6	62-5	4.0-0.4	621- 66	41-4	ND	36-6	15-5	2-1	-
	1981	6	62-5	5.0-0.8	954- 66	86-41	ND	26-9	9-3	ND	-
	1982	6	58-2	3.7-0.4	353- 70	28-20	ND	22-1	3-0	3-1	ND
	1983	7	68-3	5.2-0.4	537-122	48-7	ND	21-2	5-1	13-3	ND
	1985	7	65-3	5.9-0.7	524-152	48-21	ND	11-4	ND	10-7	TR
	1987	6	66-3	5.2-0.6	235- 33	31-4	ND	9-2	TR	2-0	TR
TORONTO HARBOUR	1979	8	46-3	5.1-1.0	423-105	82-17	TR	16-2	15-3	1-1	-
	1987	5	41-4	2.7-0.4	132- 25	20-2	ND	4-2	ND	ND	ND
LESLIE SPIT	1987	4	45-3	3.4-0.3	185- 18	20-3	ND	ND	ND	ND	ND
BLUFFERS PARK	1987	5	48-4	3.4-0.3	ND	6-2	ND	3-1	ND	ND	ND
ROUGE RIVER	1979	5	45-4	3.2-0.2	82- 35	26-13	ND	TR	6-2	TR	-
	1987	5	57-4	2.7-1.0	78- 17	26-6	ND	TR	ND	ND	ND

APPENDIX II: (cont.- page 10)

SAMPLING SITE	YEAR	n	TOTAL LENGTH (mm)	FAT (%)	PCB (ng/g)	DDT (ng/g)	MIREX (ng/g)	CHLOR DANE (ng/g)	BHC (ng/g)	HCB (ng/g)	OCS (ng/g)
LAKE ONTARIO											
DUFFIN CREEK	1980	7	62-3	2.8-0.3	111- 20	42-8	ND	10-5	5-1	ND	ND
OSHAWA CREEK	1982	4	57-11	5.8-0.9	227- 40	27-6	9-4	19-4	6-1	2-0	4-4
DARLINGTON BEACH	1975	5	58-4	4.9-0.8	420-116	94-29	ND	ND	ND	ND	-
	1976	10	61-3	5.1-0.7	360- 79	75-9	6-2	19-7	6-1	2-1	-
GANARASKA RIVER	1980	7	57-9	4.5-0.7	1202-449	170-38	7-5	13-9	11-13	2-2	-
	1982	2	67-2	7.4-0.0	533-10	117-1	22-4	16-3	9-1	3-0	6-0
GAGES CREEK	1979	3	49-3	6.0-0.1	197- 12	47-19	6-1	20-2	10-1	2-0	-
COBOURG CREEK	1978	8	50-5	5.0-1.0	270- 53	77-22	19-4	26-8	9-4	1-1	-
PRESQUILE PARK	1975	6	54-4	2.5-0.4	505- 89	82-12	ND	TR	ND	ND	-
	1979	8	49-3	3.4-0.7	122- 22	37-10	ND	8-5	ND	TR	-
NAPANEE RIVER	1988	5	44-3	2.2-0.2	162-51	9-5	ND	ND	ND	ND	ND
OUTLET RIVER	1979	8	53-3	4.3-1.2	112- 32	58-10	10-3	37-7	14-6	1-1	-
	1980	7	53-4	4.8-0.4	185- 48	52-9	8-2	22-3	8-1	TR	-
	1982	7	49-1	4.8-0.3	128- 17	7-2	7-2	12-5	4-2	1-1	1-0
	1984	7	43-6	3.1-0.6	112- 15	17-2	5-2	ND	ND	TR	1-1
	1986	7	41-5	3.3-0.5	26- 17	9-4	ND	ND	ND	2-1	ND
GLENORA	1975	5	58-4	2.9-0.3	111- 27	41-7	ND	ND	ND	ND	-
WOLFE ISLAND	1982	6	54-2	4.0-0.4	121- 48	33-8	8-3	ND	5-1	1-0	2-1
	1983	7	65-4	2.9-0.4	81- 15	16-5	7-1	TR	ND	TR	TR
	1984	7	58-5	3.6-0.2	90- 11	10-2	7-1	ND	TR	TR	TR
	1986	7	47-6	2.8-0.4	29- 21	15-3	ND	ND	ND	ND	ND
	1987	7	63-4	2.5-0.5	33- 17	7-5	24-3	ND	ND	2-1	ND
	1988	7	50-1	1.6-0.2	31- 26	2-2	ND	ND	ND	ND	ND
CATARAQUI RIVER	1980	7	59-3	3.2-0.3	99- 10	9-2	ND	5-2	3-0	1-1	-

APPENDIX II: (cont.- page 11)

SAMPLING SITE	YEAR	n	TOTAL LENGTH (mm)	FAT (%)	PCB (ng/g)	DDT (ng/g)	MIREX (ng/g)	CHLOR DANE (ng/g)	BHC (ng/g)	HCB (ng/g)	OCS (ng/g)
ST.LAWRENCE RIVER											
MAITLAND	1983	5	56-4	2.0-0.5	148- 73	22-6	ND	ND	ND	2-1	1-0
	1985	5	56-1	2.3-0.3	72- 27	10-3	ND	ND	ND	5-3	ND
	1988	7	39-2	2.7-0.9	ND	6-4	ND	ND	ND	2-1	ND
MORRISBURG	1988	6	55-2	1.5-0.2	ND	6-3	ND	ND	ND	ND	ND
MACDONNELL ISLAND	1979	8	49-5	1.5-0.6	ND	79-20	ND	9-2	ND	ND	-
	1987	7	57-5	2.1-0.3	36- 19	8-2	ND	ND	ND	ND	ND
	1988	7	50-2	1.3-0.2	ND	2-2	ND	ND	ND	TR	ND
BRIDGE-CORNWALL IS	1987	7	51-1	1.9-0.2	182-62	12-2	ND	ND	ND	ND	TR
CORNWALL MARINA	1979	3	50-3	3.6-1.2	243- 31	62-14	7-1	8-4	7-3	3-1	-
	1980	4	55-3	4.1-0.8	367-100	50-10	12-2	5-7	4-5	2-1	-
	1981	4	52-3	2.0-0.0	234- 34	22-8	8-2	5-2	2-1	ND	-
	1983	5	51-4	2.8-0.3	199- 71	25-12	8-5	2-1	ND	2-1	2-1
	1987	7	56-4	1.9-0.3	37- 20	5-3	ND	ND	ND	ND	ND
	1988	7	53-1	2.5-0.5	161-43	19-9	ND	ND	ND	ND	ND
CORNWALL ISLAND N.	1987	7	52-1	1.9-0.2	58-44	8-8	ND	ND	ND	ND	ND
	1988	7	50-1	2.4-0.4	261-65	46-17	ND	ND	ND	ND	ND
TRAINING INSTITUTE	1987	7	52-1	2.1-0.2	38-19	7-1	ND	ND	ND	ND	ND
PILON ISLAND	1987	5	53-1	2.4-0.2	92-4	8-5	ND	ND	TR	ND	ND
	1988	7	48-2	2.5-0.4	74-48	9-8	ND	ND	ND	ND	ND
THOMPSON ISLAND	1987	7	49-1	2.1-0.3	46-24	7-3	ND	ND	ND	ND	ND
	1988	7	43-1	1.9-0.1	23-22	3-3	ND	ND	ND	ND	ND
RAISIN RIVER	1987	7	56-1	3.3-0.4	36-10	6-2	ND	ND	ND	TR	ND
POINT MOUILLEE	1987	3	53-2	2.0-0.6	30-35	2-2	ND	ND	ND	ND	ND
GRASS RIVER	1979	7	51-2	1.9-0.4	2072-187	95-14	TR	18-10	4-1	ND	-
	1981	7	53-2	1.7-0.3	1117-235	39-13	8-5	4-2	TR	ND	-
	1983	6	52-4	1.6-0.2	954-343	5-4	6-2	ND	ND	ND	2-2
	1987	7	53-3	1.7-0.2	953-197	15-2	ND	ND	ND	ND	ND
	1988	7	50-3	3.1-0.2	7729-2027	ND	ND	7-8	ND	ND	ND
G.M.PLANT	1987	7	50-1	1.4-0.2	1262-324	30-10	ND	ND	ND	ND	ND
	1988	7	45-1	2.0-0.6	21529-4299	ND	ND	3-2	ND	3-3	ND
RAQUETTE RIVER	1979	7	50-2	2.1-0.5	377- 81	92-25	6-4	21-9	6-2	ND	-
	1987	5	53-4	1.5-0.2	84- 17	5-3	ND	ND	2-2	ND	2-1
	1988	7	50-1	3.0-0.4	1837-455	22-8	ND	ND	ND	ND	ND

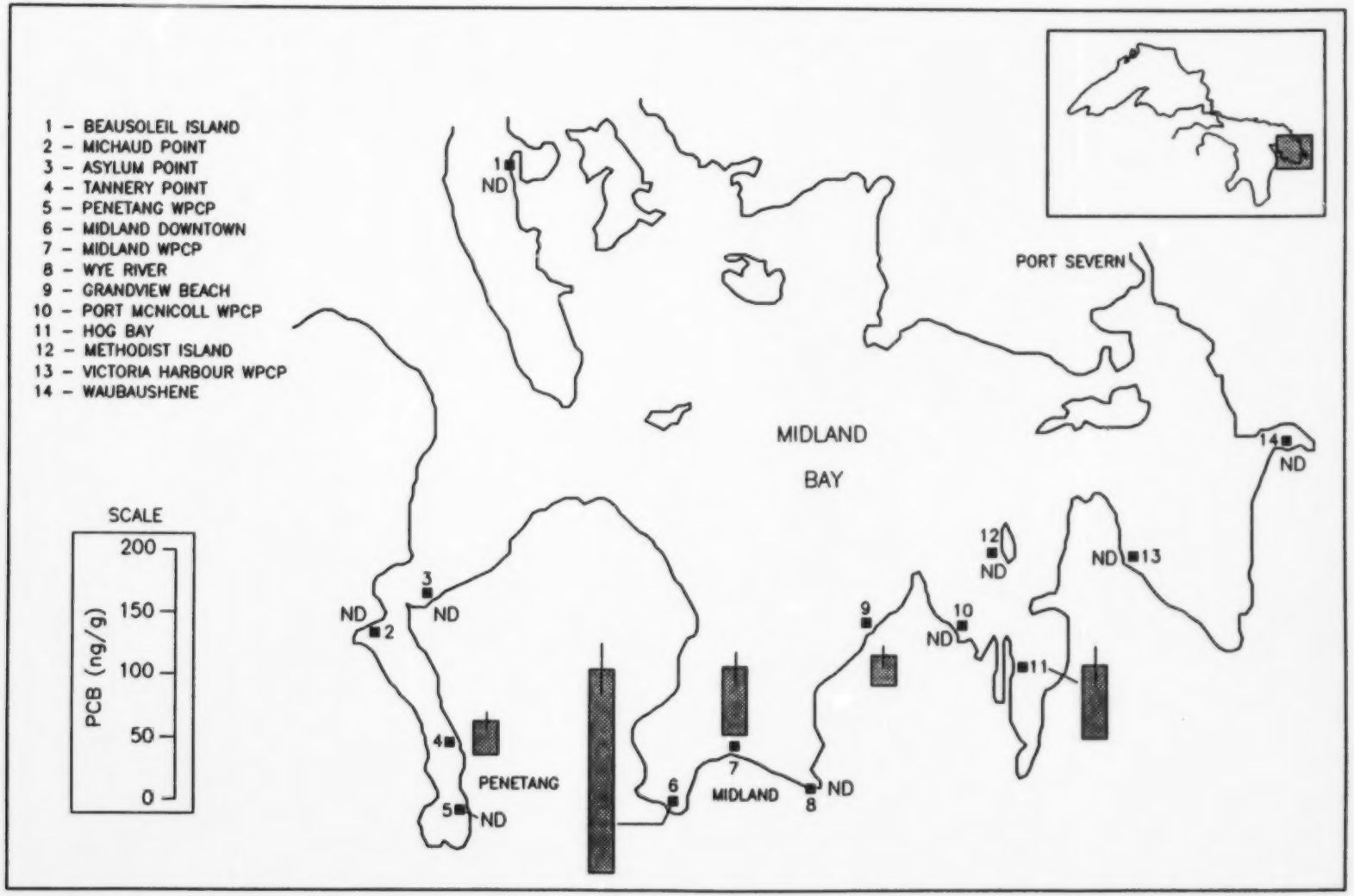
APPENDIX II: (cont.- page 12)

SAMPLING SITE	YEAR	n	TOTAL LENGTH (mm)	FAT (%)	PCB (ng/g)	DDT (ng/g)	MIREX (ng/g)	CHLORDANE (ng/g)	BHC (ng/g)	HCB (ng/g)	OCS (ng/g)
ST.LAWRENCE RIVER											
CORNWALL ISLAND S.	1987	7	48-1	2.1-0.4	252-83	24-8	ND	ND	ND	ND	1-1
	1988	7	50-1	2.1-0.3	164-38	7-6	ND	ND	ND	1-1	ND
REGIS RIVER	1987	7	52-1	2.1-0.2	126-30	7-2	ND	ND	ND	ND	TR
	1988	2	52-2	4.0-0.8	333-152	6-8	ND	ND	ND	ND	ND
REGIS CHANNEL	1987	7	50-1	2.1-0.3	91-21	6-6	ND	ND	ND	ND	ND
SALMON RIVER	1987	7	53-2	2.3-0.2	59-12	27-26	ND	ND	ND	ND	ND
POINT DUPUIS	1987	6	59-1	2.9-0.2	68-16	5-1	ND	2-1	ND	ND	1-1

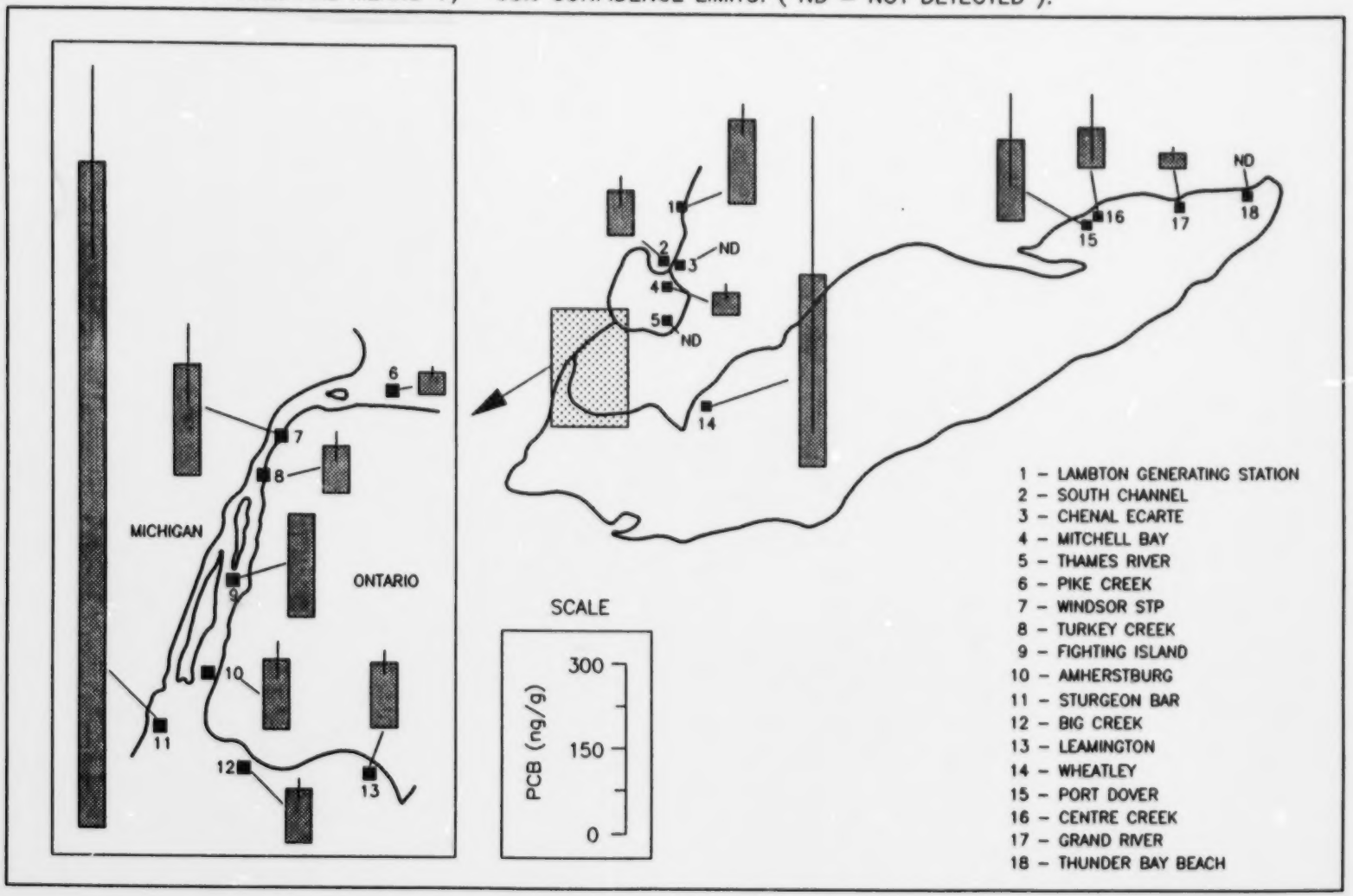
APPENDIX III: POLYNUCLEAR AROMATIC HYDROCARBON (PAH) CONCENTRATIONS IN YOUNG-OF-THE-YEAR SPOTTAIL SHINERS IN THE GREAT LAKES AND CONNECTING CHANNELS. (ND = NOT DETECTED).

COLLECTION SITE	YEAR SAMPLED	NO.OF COMPOSITE SAMPLES	MEAN TOTAL PAH (ng/g)	QUANTIFIABLE PAH
LAKE SUPERIOR				
KAM RIVER	1986	1	39	phenanthrene
GOULAIS BAY	1986	1	48	phenanthrene
GOULAIS BAY	1987	2	27	naphthalene
LAKE HURON				
LITTLE LAKE GEORGE	1987	2	23	naphthalene
COLLINGWOOD HARBOUR	1987	3	232	fluoranthene (59) pyrene (58) fluorene (48) phenanthrene (34) naphthalene (33)
SYDENHAM RIVER	1987	1	ND	
LAKE ST.CLAIR				
MITCHELL BAY	1986	1	86	phenanthrene
DETROIT RIVER				
AMHERSTBURG	1986	1	68	phenanthrene
STURGEON BAR, MICH.	1986	1	ND	
LAKE ERIE				
PORT STANLEY	1986	1	ND	
LAKE ONTARIO				
BURLINGTON BEACH	1986	1	ND	
OAKVILLE CREEK	1987	2	ND	
HUMBER RIVER	1987	1	166	naphthalene (60) fluorene (44) phenanthrene (39) acenaphthene (23)
WOLFE ISLAND	1986	1	62	pyrene
TRENT RIVER	1987	2	377	phenanthrene (124) fluorene (91) naphthalene (75) acenaphthene (51) fluoranthene (36)

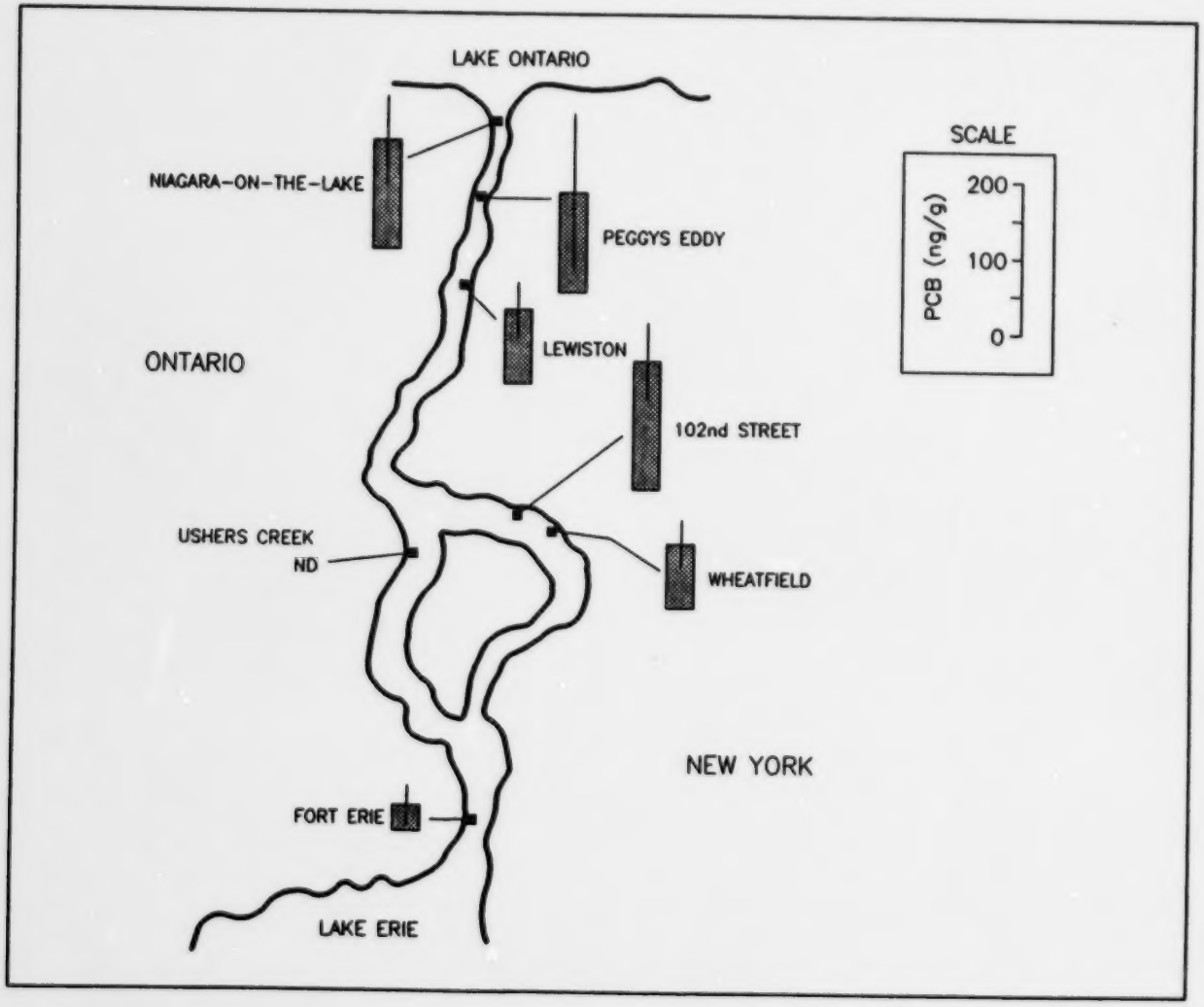
APPENDIX IV: SPOTTAIL SHINER COLLECTION SITES AND SPATIAL DISTRIBUTION OF Σ PCB CONCENTRATIONS IN YOUNG-OF-THE-YEAR SPOTTAIL SHINERS FROM SEVERN SOUND FOR 1987. VALUES ARE MEANS +/- 95% CONFIDENCE LIMITS. (ND = NOT DETECTED).



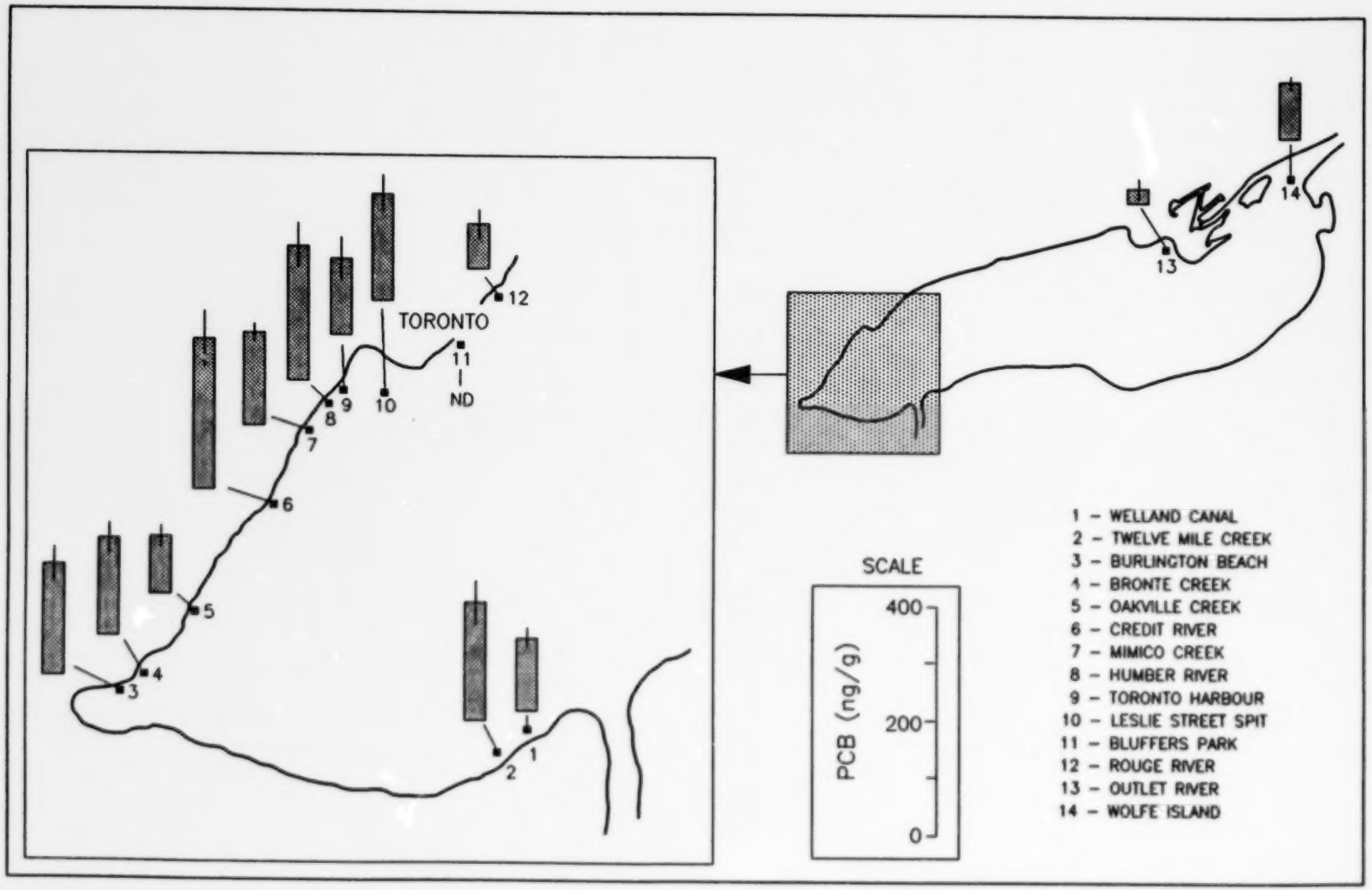
APPENDIX V: SPOTTAIL SHINER COLLECTION SITES AND SPATIAL DISTRIBUTION OF Σ PCB CONCENTRATIONS IN YOUNG-OF-THE-YEAR SPOTTAIL SHINERS FROM THE ST.CLAIR RIVER, LAKE ST.CLAIR, THE DETROIT RIVER AND LAKE ERIE FOR THE MOST RECENT YEAR, 1986, 1987 OR 1988. VALUES ARE MEANS +/- 95% CONFIDENCE LIMITS. (ND = NOT DETECTED).



APPENDIX VI: SPOTTAIL SHINER COLLECTION SITES AND SPATIAL DISTRIBUTION OF Σ PCB CONCENTRATIONS IN YOUNG-OF-THE-YEAR SPOTTAIL SHINERS FROM THE NIAGARA RIVER FOR THE MOST RECENT YEAR, 1986, 1987 OR 1988. VALUES ARE MEANS +/- 95% CONFIDENCE LIMITS. (ND = NOT DETECTED).



APPENDIX VII: SPOTTAIL SHINER COLLECTION SITES AND SPATIAL DISTRIBUTION OF Σ PCB CONCENTRATIONS (ng/g) IN YOUNG-OF-THE-YEAR SPOTTAIL SHINERS FROM LAKE ONTARIO FOR THE MOST RECENT YEAR, 1986, 1987 OR 1988. VALUES ARE MEANS +/- 95% CONFIDENCE LIMITS.

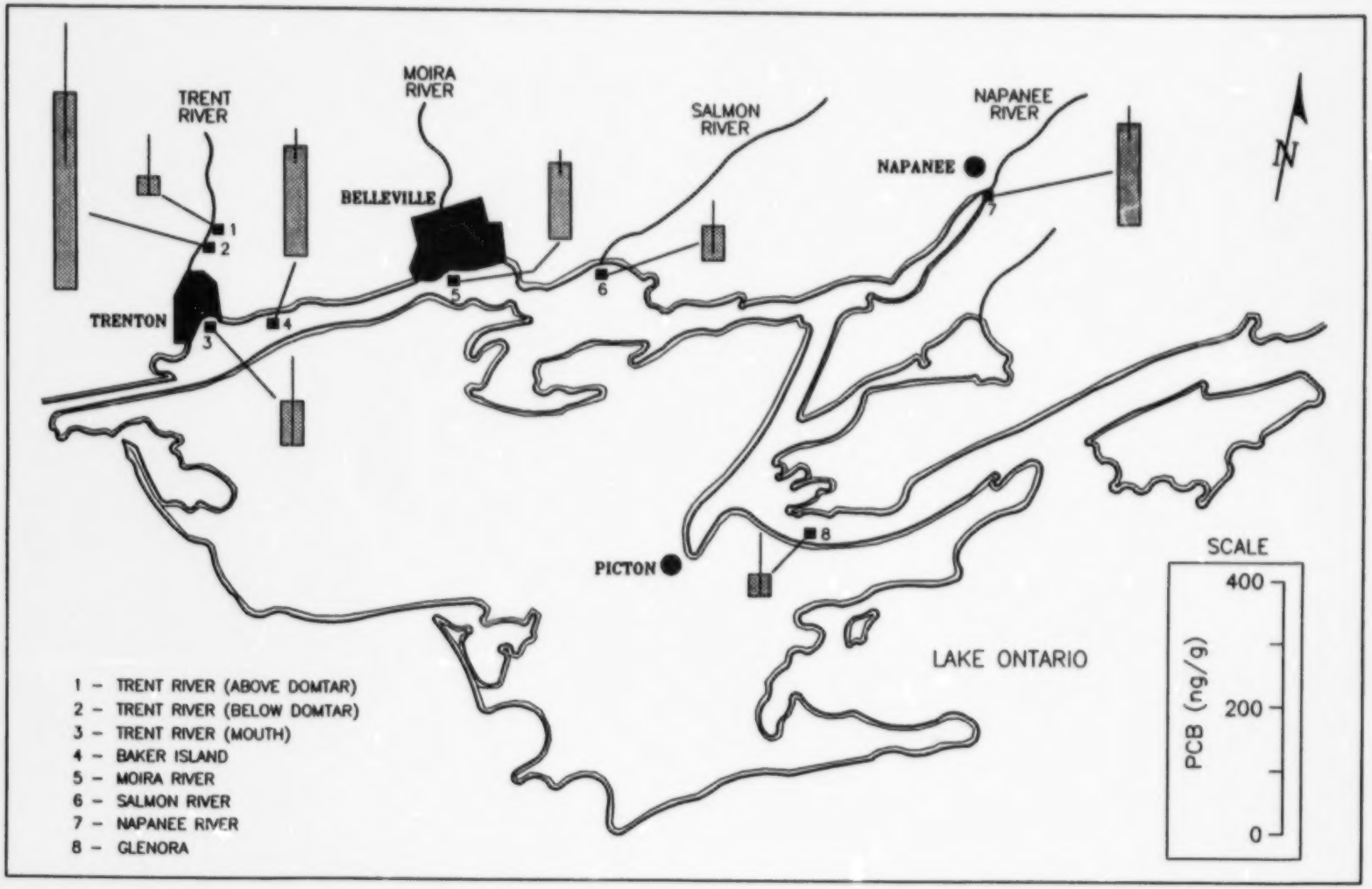


APPENDIX VIII: ORGANOCHLORINE CONTAMINANT CONCENTRATIONS IN YOUNG-OF-THE-YEAR YELLOW PERCH IN THE BAY OF QUINTE. VALUES ARE MEANS +/- STANDARD DEVIATION. (T = TRACE, ND = NOT DETECTED, NA = NOT AVAILABLE).

SAMPLING SITE	YEAR	n	TOTAL LENGTH (mm)	FAT (%)	PCB (ng/g)	DDT (ng/g)	MIREX (ng/g)	HCB (ng/g)	OCS (ng/g)	PENTA CHLORO PHENOL (ng/g)
ABOVE DOMTAR	1987	3	72-1	2.0-0.6	23-23	4-3	ND	2-2	2-1	ND
BELOW DOMTAR	1985	7	72-2	2.3-0.3	415-152	43-12	ND	2-2	ND	ND
	1987	3	67-2	2.4-0.4	68-20	11-2	ND	1-1	2-1	197-136
	1988	3	68-1	4.0-0.1	310-35	2-3	ND	2-1	ND	1963-968
TRENT RIVER (MOUTH)	1979	8	66-1	2.7-0.4	346-36	43-7	ND	ND	NA	NA
	1982	6	69-2	2.8-0.3	208-37	32-8	TR	ND	ND	NA
	1985	7	72-2	2.2-0.3	183-84	32-22	ND	3-2	ND	NA
	1986	7	68-2	2.5-0.4	103-18	20-4	ND	ND	1-1	NA
	1987	3	64-1	2.0-0.4	70-26	17-4	ND	1-1	3-2	ND
BAKER ISLAND	1988	3	67-1	2.3-0.2	173-12	18-2	ND	TR	ND	NA
MOIRA RIVER	1978	8	64-1	1.7-0.2	308-79	15-3	ND	5-1	NA	NA
	1988	8	68-2	2.7-0.2	120-18	20-2	ND	ND	ND	NA
SALMON RIVER	1988	3	64-2	2.0-0.2	55-13	12-1	ND	ND	ND	NA
** NAPANEE RIVER	1988	5	44-3	2.2-0.2	162-22	9-5	ND	ND	ND	NA
GLENORA	1988	3	69-2	3.4-0.4	35-25	15-3	ND	1-1	ND	NA

** - young-of-the-year spottail shiners

APPENDIX IX: YELLOW PERCH COLLECTION SITES AND SPATIAL DISTRIBUTION OF Σ PCB CONCENTRATIONS IN YOUNG-OF-THE-YEAR YELLOW PERCH FROM THE BAY OF QUINTE FOR THE MOST RECENT YEAR, 1986, 1987 OR 1988. NAPANEE RIVER FISH ARE YOUNG-OF-THE-YEAR SPOTTAIL SHINERS. VALUES ARE MEANS +/- 95% CONFIDENCE LIMITS.



APPENDIX X: SPOTTAIL SHINER COLLECTION SITES AND SPATIAL DISTRIBUTION OF Σ PCB CONCENTRATIONS (ng/g) IN YOUNG-OF-THE-YEAR SPOTTAIL SHINERS FROM THE ST. LAWRENCE RIVER FOR THE MOST RECENT YEAR, 1986, 1987 OR 1988. VALUES ARE MEANS +/- 95% CONFIDENCE LIMITS. (ND = NOT DETECTED).